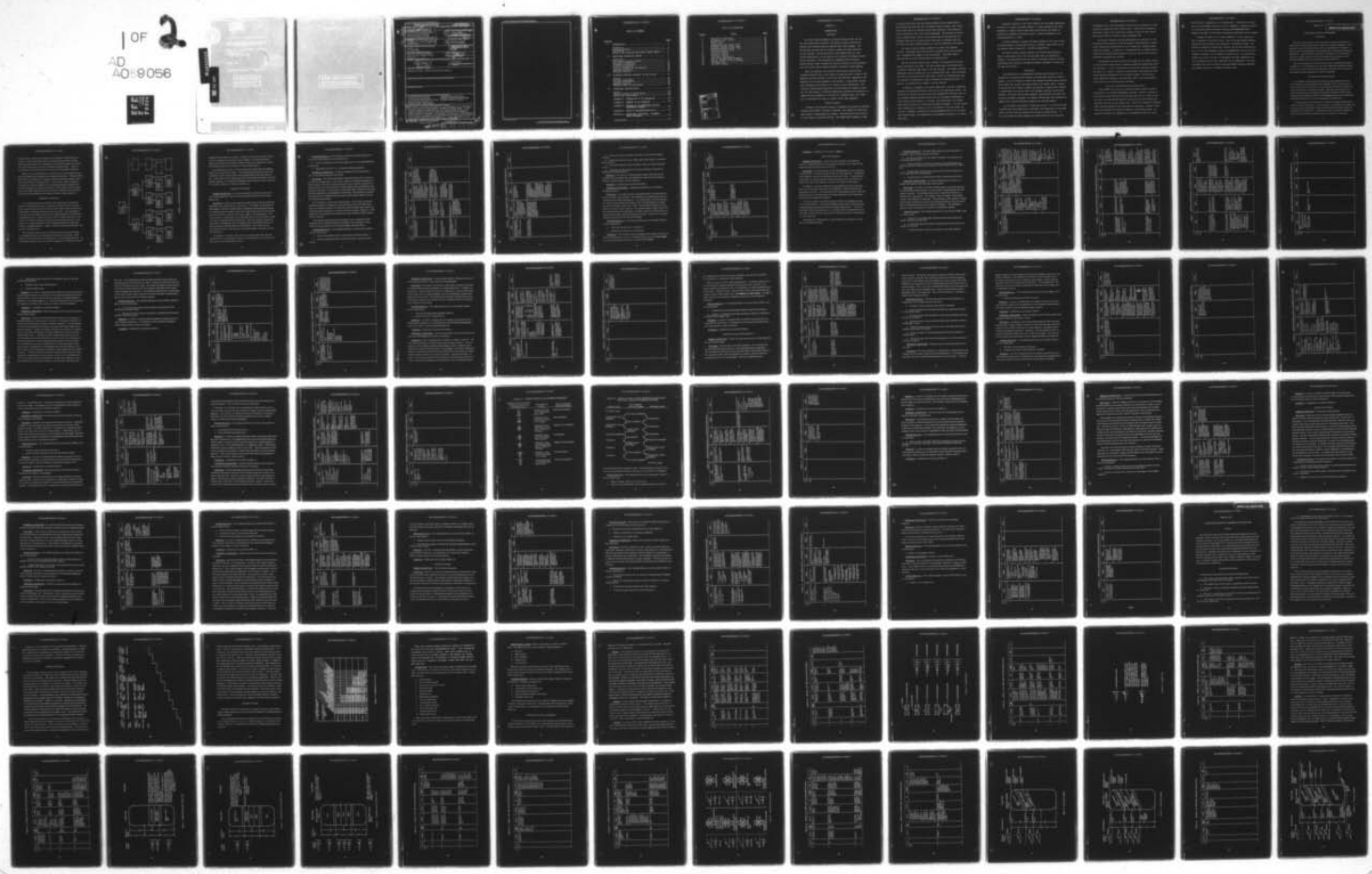
AD-A069 056 LOGICON INC SAN DIEGO CALIF F/G 5/9
GROUND CONTROLLED APPROACH CONTROLLER TRAINING SYSTEM TRAINING/--ETC(U)
DEC 78 M HICKLIN, L H NOWELL, R PETERSEN N61339-77-C-0162
UNCLASSIFIED NAVTRAEQUIPC-77-C-0162-1 NL



SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NAVTRAEQUIPCEN 77-C-0162-1	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Ground Controlled Approach Controller Training System Training/Functional Design Report	5. TYPE OF REPORT & PERIOD COVERED: Interim Report Oct 1977 — Feb 1978
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): Mary Hicklin, Larry Holmes Nowell, Rohn Petersen	8. CONTRACT OR GRANT NUMBER(s): N61339-77-C-0162
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Logicon, Inc. P.O. Box 80158 San Diego, California 92138	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NAVTRAEQUIPCEN Task No. 7796-1P1
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Training Equipment Center Code N-71 Orlando, Florida 32813	12. REPORT DATE: December 1978 13. NUMBER OF PAGES: 151
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 149 p.	15. SECURITY CLASS. (of this report): Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ground Controlled Approach
Controller Training System
GCA Controller Behavioral Objectives
Automated Speech Recognition
Automated Speech Understanding
Automated Speech Generation
Automated Performance Measurement
Automated Adaptive Training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is the baseline document for the development of an experimental prototype Ground Controlled Approach Controller Training System. It describes the behavioral objectives for the training system and the course syllabus designed to meet these behavioral objectives in an automated adaptive training environment. The syllabus is structured to take advantage of the benefits of computer aided instruction and to accord with the state of the art speech technology which supports it. A brief description of the functional requirements of the system is also included.

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S/N 0102-LF-014-6601

Unclassified
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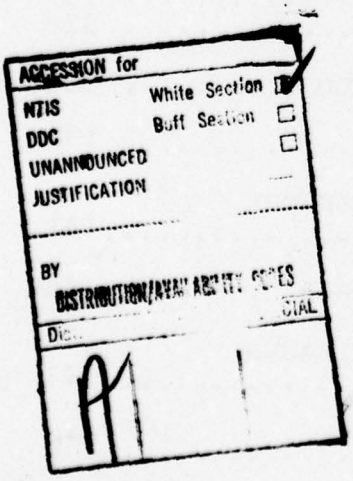

SECTION I

INTRODUCTION

Background

The Ground Controlled Approach Controller Training System, the GCA-CTS, will provide basic training in the conduct of ground controlled approaches using simulated precision approach radar (PAR) equipment. The PAR indicator provides aircraft elevation, azimuth and range information on final approach. The PAR controller's task commences when he or she assumes responsibility for the control of an aircraft after handoff from the pattern controller. That responsibility terminates when the aircraft reaches decision height, although the controller continues to give advisories until the aircraft passes landing threshold or executes a missed approach.

During the approach, the controller issues course corrections and glidepath advisories over a voice channel to enable the pilot to effect a safe approach even during periods of low ceiling and visibility, regardless of the Navigation Aid receiving equipment in the aircraft. A well-defined, precise radio terminology (R/T) serves as the vehicle for this communication. The controller training problem therefore involves teaching the student to interpret the radar display, to determine appropriate corrections and advisories, to communicate this information to the pilot in a standard format, and in addition, to coordinate with other air traffic control (ATC) personnel.

Existing Training

Presently, GCA controller training is conducted at the Naval Air Technical Training Center (NATTC), Millington, Tennessee. The students are highly motivated airmen or airmen apprentice personnel. The GCA portion of the school is the final phase of controller training. The students have completed 13 weeks

of training during which they have obtained Federal Aviation Administration certification and become familiar with weather reports, baseops, tower control, Visual Flight Rules and Instrument Flight Rules procedures, night operations, and air surveillance radar (ASR) control procedures. The PAR phase of instruction is conducted over a period of five working days by instructors who are extremely conscious of the responsibility they bear in performing their job, and insist that their students measure up to the high standards of the service.

The current training program commences on a Friday with classroom lectures. The students are given the task of learning the R/T over the weekend. Programmed texts augment the lecture material. The student begins practice with the actual training device the following week.

The GCA controller training device consists of an operational PAR radar console interfaced to the 15G19. The 15G19 accepts inputs from pseudo pilots to provide a simulated radar signal to the PAR indicator. The student controller communicates with the pseudo pilot via a simulated radio link. Since the pseudo pilot does not have access to the PAR display, he/she must depend entirely upon the controller's instructions in order to maneuver the simulated aircraft. In practice, one pseudo pilot is needed to fly each aircraft.

In addition to responses to controller advisories, a variety of parameters affecting the simulated environment can be set at the pseudo-pilot console. The 15G19 does not provide any formal instruction regarding the controller task, nor any automated adaptive problem selection facility, performance measurement, or other training system features. In general, the existing device is designed specifically to simulate an operational PAR radar environment. It is the instructor's responsibility to make use of this environment to train the student controllers. Therefore, in addition to training management duties, the instructor must provide prompts, rule explanations and performance monitoring on an individual basis.

Successful completion of the course requires that the student demonstrate the ability to conduct a precision approach. A scoring system for this final examination is employed which weighs safety errors heavily with respect to phraseology, glidepath and procedural errors. Clearly the emphasis in the training program is on safety.

Following graduation, trainees are usually assigned to the fleet to serve an apprenticeship at an operational facility. Therefore, they receive on the job training before assuming full controller responsibility.

The school conducts regular surveys of its training effectiveness by means of questionaires sent to the stations where their new graduates are employed. The responses show that the school is providing effective training. Nevertheless the curriculum is undergoing continual refinement to accord with the needs of the fleet.

The GCA-CTS

The GCA-CTS will be an experimental prototype training system (as contrasted with a training device) designed to provide basic training in GCA procedures. It will be designed to ensure that competent trainees master the basic skills within the five-day time frame allowed in the present course. Because of the GCA-CTS' many features, students are expected to complete basic training in significantly less than five days, and enrichment exercises are therefore provided. The GCA-CTS will provide automated, individualized instruction with objective performance assessment, and numerous instructional aids including programmed texts, detailed performance summaries and annotated replays.

It will benefit the students in other ways as well. It will relieve them of pseudo-pilot duties which do not contribute to the acquisition of controller skills, but which must be performed with the current training device. It will also provide the faster students with opportunities for the acquisition

of advanced skills, since post-graduate training will be available for those students who complete the basic course quickly. Another major advantage of the system is that it will relieve the instructor of many of those routine duties which encroach on his/her training management time.

The existing laboratory GCA-CTS demonstrated the feasibility of a GCA controller training system in which the student's verbal behavior is automatically monitored and scored with the aid of commercially available speech recognition hardware. In addition, it demonstrated that a syllabus could be constructed and that automated adaptive training of the task with objective performance measurement was possible.

The experimental prototype GCA-CTS will embody all the lessons learned in the laboratory system and will incorporate additional sophisticated training techniques. It will be designed for motivated and responsible students. The intent is to produce a system that will provide a challenging and interesting learning environment for the individual student. This requires a course adaptively tailored to meet individual needs, with clearly defined objectives which are challenging but attainable.

Focus of the Training/Functional Design Report

This document will serve as the baseline document during the system design phase of the GCA-CTS experimental prototype. Section II consists of the behavioral objectives which the controller must attain in order to pass the course, and some advanced behavioral objectives for those students who have time to proceed to post-graduate work. Section III contains the detailed course syllabus designed to meet the behavioral objectives. Section IV identifies and describes the functional elements of the training system. For convenient reference the vocabulary to be recognized and that to be simu-

lated are given in Appendices A and B respectively. Vocabulary to be recognized in the enrichment exercises is given in Appendix C. Appendix D details the differences between the present document and NAVTRAEQUIPCEN TN-52. Appendix E provides a cross between the behavioral objectives and the syllabus.

Although the report is by no means exhaustive, it still covers more than is required to teach basic skills. Some of the many possible advanced topics have been mentioned in the discussion of enrichment training. The GCA-CTS is intended to provide basic training, and the design approach will be to do that very thoroughly, leaving the implementation of much of the enrichment in abeyance, to be included as resources allow. The training described in the first six levels of achievement, the final examination, and the enrichment topic of no-gyro approaches will be implemented. The other enrichment topics and the specially designed remedial exercises associated with complex skills will be added as resources allow.

SECTION II

BEHAVIORAL OBJECTIVES REPORT

Objectives

The overall objective of a radar approach is to direct the aircraft to a point where a visual landing can be made in low visibility conditions. This particular area of aircraft control calls for a high degree of team work, effective use of communication and constant practice of the procedures and safeguards. Given the proper equipment, this task can be accomplished with an acceptable degree of safety, provided certain procedures, techniques and safeguards are practiced and strictly adhered to.

The overall objective of the GCA-PAR course is to enable the student to attain to a level of proficiency in the GCA control task which will qualify him or her to enter the fleet as an apprentice controller able to use precision approach radar equipment and radio terminology.

The Minimum Training Problem

As a minimal requirement ninety percent of the students trained by GCA-CTS must, upon completion of the syllabus, meet or exceed the accuracy criteria for a minimum of ninety percent of the tasks and skills defined in the behavioral objectives listing. When the actual performance measurement system is designed, the relative importance of the various behaviors will be defined to arrive at a weighting scheme for evaluating the students performance in a more meaningful and realistic way.

An agreed upon time constraint of a maximum of eight working days is also placed upon the system. Toward that end, a coherent set of trainee and training system performance criteria should be developed based upon the operational skill objectives. Performance criteria should be designed to ensure these operational skill objectives are acquired to the degree

necessary for acceptance by the fleet as an adequately trained PAR controller. A final examination shall be employed as part of the syllabus. This final examination will be designed to demonstrate whether the trainee has retained the skills necessary to perform specified tasks. This will demonstrate the effectiveness of the system in training PAR controllers.

NOTE: As the specific behavioral objectives were documented several areas of training were categorized as advanced skill areas. These advanced skill areas are specified as a separate mission and do not comprise a portion of the minimum training problem. These skills should be taught by the system as optional graduate level training following the student's successful completion of the final examination. While these skills are important in GCA-PAR approaches they are not part of the basic PAR skill that every GCA school graduate must include in his/her skills repertoire.

Hierarchy of Behaviors

As an organizational and analytical aid in dissecting the behavioral aspects of performing this task, a hierarchy of behaviors was developed. Four mission objectives were derived from the course objective which describe distinct segments of the GCA controller's task. The attainment of a mission objective requires that several complex behaviors be performed at appropriate times. Mastery of each of these complex behaviors is described as a terminal objective within the larger mission objective context. Finally, the complex behaviors can be subdivided into their constituent simple or enabling behaviors. Figure 1 shows the behavioral hierarchy for the GCA controller task.

The distinction among levels of objectives consists in the following. The enabling behaviors are independent and directly measurable. Strict standards can be defined for the performance of each enabling behavior. At the terminal objective level, the relative significance of violations of these

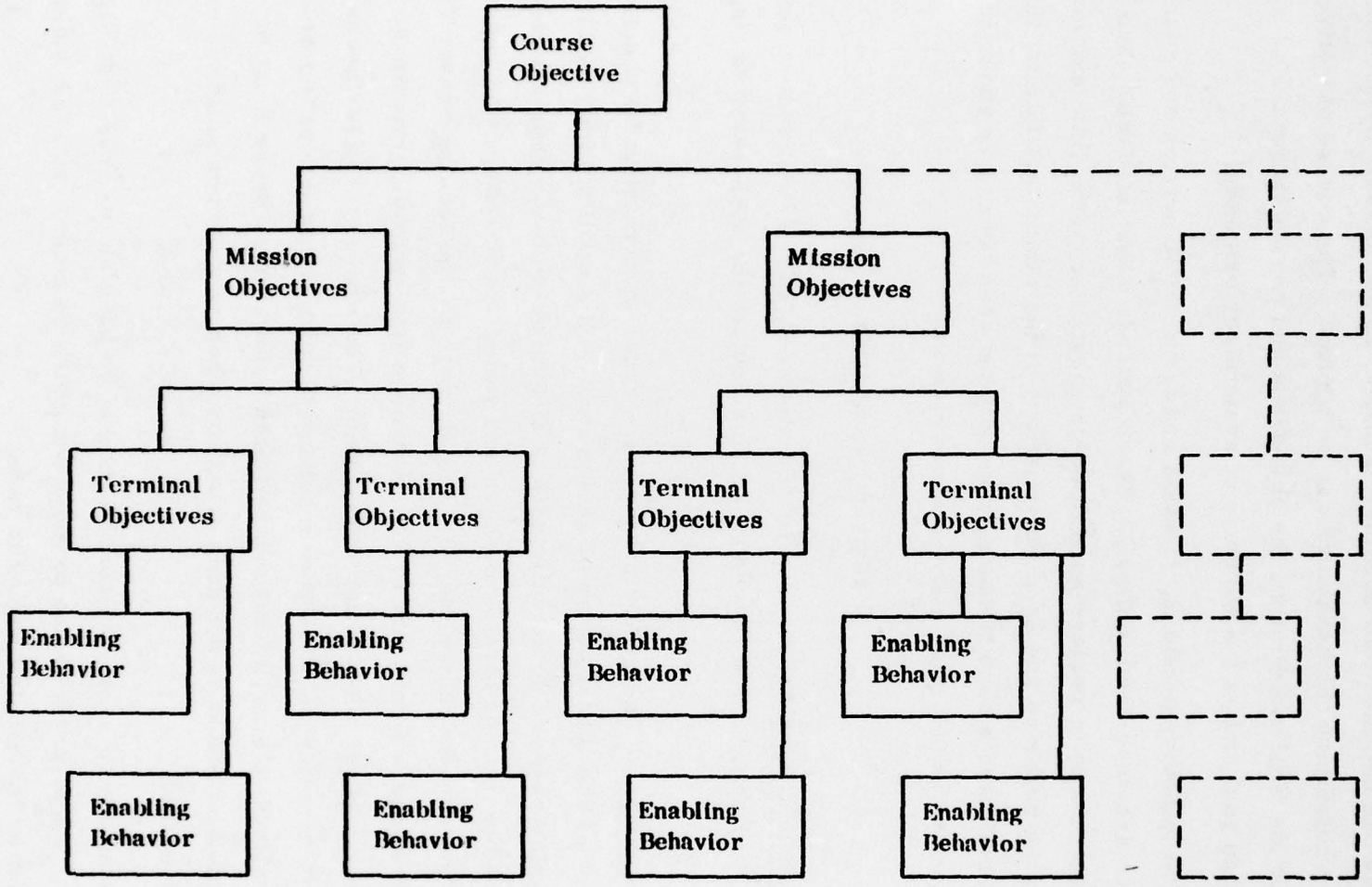

Figure 1. Hierarchy of Behaviors

standards can be taken into account. Finally, at the mission objective level, rules for combining the behaviors can be applied. The course objective stands as the final cause of all the objectives and serves therefore as a system design goal and as the measure of system performance.

In the following sections, mission and terminal objectives and enabling behaviors are described in detail. The standards associated with each level of objective refer to performance to be demonstrated in the final examination. In the behavior and condition portions of the tables that follow, the letter notation indicates a conditional relationship between behaviors and conditions. For example, behavior a relates to condition a.

Alignment Verification

MISSION OBJECTIVE — Verify the alignment of the PAR system prior to the initial approach of the watch and manipulate the PAR servo during approaches.

Discussion — The precision approach radar system must be checked for alignment as the initial action of each watch. This entails verifying that the PAR display cursors do actually reflect alignment with the physical runway. It is possible that the display cursors and range marks will not be representative of the runway centerline, the actual range or the landing area. This could introduce a significant error component into course corrections, range calls and/or glidepath position advisories. The final controller checks the alignment by adjusting the servo mechanism down and following the procedures outlined in enabling behaviors listed below. This check must be coordinated so that it is not done at a time when another controller is using the PAR radar.

The ability to servo the radar can also be used by the PAR controller whenever the aircraft begins to move out of the parameters of the radar and the target on the display begins to fade.

Terminal Objectives — The alignment verification mission objective is comprised of the following terminal objectives:

a. Verify the alignment of the PAR system prior to the initial approach of the watch.

b. Manipulate the PAR servo mechanism during approaches.

TERMINAL OBJECTIVE — Verify the alignment of the PAR system prior to the initial approach of the watch.

Discussion — The initial adjustment of the PAR system is of crucial importance to all approaches. If the radar system is improperly adjusted the PAR controller will not be advising the pilot of his aircraft's true position or altitude and the aircraft may not be over the runway at the termination of the precision approach. To avoid such a calamity the final controller must check the PAR equipment at the beginning of each watch. The procedure is simple but should not be considered trivial because of the extreme effects it has on all subsequent approaches.

The first step is to lower the azimuth radar. This is done so that the centerline reflector is displayed on the azimuth portion of the PAR scope. Once the centerline reflector is located the final controller must check to be certain that the azimuth cursor lines up with the centerline reflector. If the alignment is not perfect he must inform the radar technician that an adjustment is required.

Following the azimuth check the elevation cursor alignment and the alignment of the range marks must be checked. The procedure is quite similar to the procedure for the azimuth display described above.

Enabling Behaviors — The enabling behaviors are described in Table 1 and are listed below:

1. Lower the azimuth antenna to pick up the centerline reflector.

2. Check the alignment of the centerline reflector and the azimuth cursor.

TABLE 1. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Lower the azimuth antenna to pick up the centerline reflector and the touchdown reflector.	This action is the initial action of each watch.	a) The azimuth antenna must be lowered to a point where the centerline reflector appears on the azimuth display. b) The azimuth antenna must be lowered prior to adjusting the alignment of the system. c) The radar alignment must be checked at the beginning of each watch.	The azimuth antenna must be lowered to pick up the centerline reflector to facilitate the check of the azimuth cursor's alignment.	
2.	Check the alignment of the azimuth cursor with respect to the centerline reflector. Select: a) continue b) contact the radar technician	The azimuth antenna has been adjusted down. a) the azimuth cursor bisects the centerline reflector b) the azimuth cursor does not bisect the centerline reflector.	a) The azimuth antenna must be adjusted down prior to the azimuth alignment check. b) The azimuth cursor must bisect the centerline reflector.	The azimuth cursor should be adjusted properly so that the azimuth cursor is superimposed upon the imaginary extension of the runway centerline.	
3.	Servo the elevation antenna to the left to pick up the touchdown reflector.	The azimuth cursor and the centerline reflector have been aligned.	a) The servo must be extended to the position where the azimuth touchdown range mark and the touchdown reflector appear on the azimuth.		
4.	Check the alignment of the range marks with respect to the touchdown reflector. Select: a) continue b) contact the radar technician	The elevation antenna has been adjusted left. a) the touchdown range mark touches the leading edge of the touchdown reflector. b) the touchdown range mark does not touch the leading edge of the touchdown reflector.	The touchdown range mark must touch the leading edge of the touchdown reflector.		

TABLE 1. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
5.	Check the alignment of the elevation cursor with respect to the touchdown reflector. Select: a) continue b) contact the radar technician	The azimuth cursor has been adjusted. a) the elevation cursor intercepts the upper 1/3 of the touchdown range mark. b) the elevation cursor does not intercept the upper 1/3 of the touchdown range mark.	a) The elevation cursor must intercept the upper 1/3 of the touchdown range mark.		
6.	Raise the azimuth antenna to pick up incoming aircraft and reposition the elevation antenna.	The azimuth cursor has been aligned with respect to the centerline reflector and is still in a lowered position. The elevation cursor has been aligned with the touchdown reflector and is still positioned to the left of the centerline.	a) The azimuth antenna must be raised and the elevation antenna moved to the left following the check or adjustment of the cursor-reflector alignments. b) The azimuth antenna must be raised high enough that the one mile range mark is bisected by the elevation cursor and the top of the two mile mark is just touching the elevation cursor. c) The elevation antenna must be returned to a position where the azimuth cursor bisects the one mile azimuth range mark.		

3. Servo the elevation antenna to the left to pick up the touchdown reflector.

4. Check the alignment of the range marks with respect to the touchdown reflector.

5. Check the alignment of the touchdown reflector and the elevation cursor.

6. Raise the azimuth antenna to pick up incoming aircraft and reposition the elevation antenna.

Standards — In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in table 1 must be achieved.

Conditions — Conditions are provided in Table 1.

TERMINAL OBJECTIVE — Manipulate the PAR servo mechanism during approaches.

Discussion — The PAR controller frequently needs to adjust the direction of the radar scan patterns. The adjustment is mandated when the aircraft leaves the radar scan patterns. It is interesting to note that the proper response to the fading of the target on the azimuth display is to adjust the servo mechanism either up or down. This procedure appears at first glance to be quite counter intuitive. The system begins to make sense when one realizes that the azimuth radar is bounded in terms of elevation and is, practically speaking, unbounded along the azimuth. The same sort of logic applies when discussing the elevation display.

Enabling Behaviors — The enabling behaviors are described in Table 2 and are listed below.

1. Adjust the azimuth servo mechanism.

2. Adjust the elevation servo mechanism.

Standards — The aircraft must not disappear from either one of the displays more than twice, nor for a combined total of more than ten seconds, nor from both displays at once for more than five seconds.

TABLE 2. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Adjust the azimuth servo mechanism: a) up b) down	a) The aircraft goes above the scan of the azimuth antenna and therefore fades on the azimuth display. b) The aircraft goes below the scan of the azimuth antenna and therefore fades on the azimuth display. c) As the aircraft moves out of the azimuth radar scan pattern, the target progressively fades on the display.	The target must not completely disappear from the azimuth display for more than five seconds.		If the target disappears for 10 seconds the run will be terminated.
2.	Adjust the elevation servo mechanism: a) right b) left	a) The aircraft goes to the right of the scan of the elevation antenna and therefore fades on the elevation display. b) The aircraft goes to the left of the scan of the elevation antenna and therefore fades on the elevation display. c) As the aircraft moves out of the elevation antenna scan pattern the target progressively fades on the display.	The target must not completely disappear from the elevation display for more than five seconds.		

Conditions – Conditions are provided in **Table 2.**

Initial PAR Approach

MISSION OBJECTIVE – Conduct the initial portions of the PAR approach. Accept the handoff from the pattern controller and conduct the approach through the begin descent advisory.

Discussion – The initial phase of each PAR approach is very important to the safe and successful execution of the aircraft's approach. Perhaps the most important aspect to be discussed is the turn to final. In executing the turn to final, the final controller instructs the pilot to turn so that the aircraft's new course will bring the aircraft to the center of the runway.

In addition to the final controller's transmitting the correct turn headings, the turn to final course will be facilitated by a skillful handoff from the pattern controller. The handoff involves instructing the pilot to turn onto dogleg as well as communicating to the final controller all the information he will need to conduct the approach.

The initial portion of the PAR approach entails two additional actions by the final controller. The initial glidepath reports inform the pilot that he is approaching the glidepath and that he should begin descent. "Do not acknowledge further transmissions" is an advisory that is transmitted for the convenience of both the pilot and the final controller as well as contributing to a safe approach.

Standards for completing this mission objective are identical to those for each enabling behavior.

Terminal Objectives – The initial PAR approach mission objective is comprised of the following terminal objectives:

a. Accept the handoff from the pattern controller and establish communications with the pilot.

b. Instruct the pilot to turn his aircraft to a given heading that will allow the aircraft to intercept and remain in contact with the course centerline.

c. Provide initial reports to the pilot on the aircraft's position relative to interception with the glidepath.

d. Transmit the do not acknowledge further transmissions advisory.

TERMINAL OBJECTIVES – Accept the handoff from the pattern controller and establish communications with the pilot.

Discussion – The final controller's initial action on each PAR approach is to accept the handoff and hence aircraft control responsibilities from the pattern controller. The handoff sequence has a rigid structure that is a mainstay in all approaches. The sequence does not change, except superficially, from approach to approach. The uniformity of the sequence assures that the final controller receives all the information that he will need to conduct a safe PAR approach from the pattern controller. The enabling objectives reflect the sequence of events for accepting the handoff.

Enabling Behavior – The enabling behaviors are described in Table 3 and are listed below.

1. Monitor the communications channel and the dialog between the pattern controller and the pilot.

2. Acknowledge that the handoff communication from the pattern controller was received.

3. Confirm that the aircraft is represented on the PAR indicator.

TABLE 3. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	The final controller monitors the communications channel and the dialogue between the pattern controller and the pilot.	The pattern controller uses the ICS system to issue a handoff message. The message is of the following format and is designated for the student's position (variable). "Position $\underline{X_1}$, handoff, $\underline{1}$, $\underline{2}$, $\underline{3}$, button, X_2." where: X_1 - a numeral, 1, 2 or 3 to indicate which final controller the handoff is intended for 1 - the aircraft's current position possibilities: a. right base b. left base c. range & bearing 2 - the aircraft's call sign format: Navy $\underline{XXX}$, Army $\underline{XXX}$, Marine $\underline{XXX}$, or Air Force $\underline{XXX}$ where X is a digit 0-9. 3 - type of aircraft 4 - the type of approach. For example: a. full stop b. low approach c. touch and go X_2 - remote selection number representing the radio frequency on which the pilot is communicating	a) The communications channel given in the handoff message must be monitored by the final controller. b) The communications channel given in the handoff message should not be monitored if the handoff is not designated for the student's position. c) The final controller must monitor a communications channel when a handoff is directed to the student's position.	The word "handoff" identifies the message as a handoff to the final controller. The final controller must extract from the handoff message the following information: a) the final controller for which the handoff is intended b) the aircraft's call sign c) the aircraft's position d) the type of approach e) the button number for the aircraft's communication frequency. f) type of aircraft.	Pattern controller handoff to positions other than the student's should be included in each simulation. To speed up the session these handoffs can be waved off or directed to a runway other than the one the student will be using. One minute after the pattern controller issues the handoff the aircraft appears on the final controller's PAR indicator as a target. While monitoring the communications channel the final controller listens to the pattern controller issue the following instructions: a) Missed approach instructions: "Your missed approach procedure is climb and maintain 1500, turn right heading 300, over". b) final turn to dogleg: Right base 1. "Turn right heading 130, over" OR 2. "Turn right heading 140, over". Left base 1. "Turn left heading 180, over". OR 2. "Turn left heading 190, over".

TABLE 3. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
1. (cont)					OR if the pilot is executing a low approach c) low approach instructions: "After completing low approach climb and maintain 1500, turn right, heading 270, over"
2.	The final controller acknowledges the handoff message so that the pattern controller knows his handoff was acted upon. The acknowledgement is in the form of: "Position X, roger".	The handoff message has been issued by the pattern controller. The final controller is monitoring the proper communications channel.	a) The final controller must acknowledge every handoff designated for his position. b) The acknowledgement must be made within ten seconds following the handoff communication c) Proper R/T must be used as described in Appendix A, phrase 1.		If the final controller does not acknowledge the handoff within ten seconds of its issuance, the pattern controller reissues the handoff. If after another ten seconds the final controller still does not acknowledge the handoff, the pattern controller responds: "Position X, did you copy." If still no response after five seconds the pattern controller responds: "Position X, over" The pattern controller will then terminate the approach if he receives no response within five seconds of his last message.
3.	The final controller confirms that the aircraft has appeared as a target on his display: "C/S, radar, button X."	The handoff has been made by the pattern controller and acknowledged by the final controller. The target appears on the right or left side of the PAR display.	a) Fifty percent of the azimuth target must be on the radar display when the final controller reports radar contact. b) The final controller must report the proper call sign and button numbering.	The final controller must know the aircraft's position and the PAR radar display area so that he reports radar contact only when the target appears on the display.	Occasionally, extraneous targets appear on the display, so that the final controller must discriminate between these and the target. The pattern controller acknowledges the final controller's report of radar

TABLE 3. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
3. (cont)			c) The final controller must confirm radar contact within ten seconds of the target appearing on the PAR display. d. Proper R/T must be used as described in Appendix A, phrase 2.		contact by deselecting the radio frequency transmit button.
4.	The final controller asks the pattern controller for control of the communications frequency. The final controller uses "Give me button X."	The final controller has reported radar contact. The amber light on the radio console panel does not go out.	a) If the amber light on the radio console does not go out the final controller must request control of the frequency. b) Proper R/T must be used as described in Appendix A, phrase 3. c) The request must be made within fifteen seconds of his report of radar contact.	The pattern controller acknowledges the final controller's report of radar contact by deselecting the transmit button on the radio console light system.	
5.	The final controller establishes radio contact with the aircraft by: a) selecting the transmit button of the proper frequency on the radio console. b) Inquiring of the pilot: "C/S, this is your final controller, how do you hear me?" c) The final controller responds to the pilot's weak signal report by: 1) readjusting the microphone 2) transmitting: "How do you hear me now?" d) Radio contact can be established by substituting the	a, b, d) Radar contact has been reported by the final controller and acknowledged by the pattern controller. c) V. U. level of radio contact message is low The pilot responds to the initial message with "Weak but clear" d) The target is approaching the course or glidepath cursor(s) very rapidly.	a) Establishing radio contact is always the final controller's first interaction with the pilot. b) Proper R/T must be used as described in Appendix A, phrase 4, 5, 6, 7, or 8. c) Radio contact must be established with the pilot within thirty seconds of the target appearing on the PAR display. d) The correct radio frequency must be used. e) The final controller must respond to the pilot's "Weak but clear" report.	Establishing radio contact is essential for a safe approach.	The pilot responds to the final controller's message with: a) "loud and clear" b) if the V. U. level is low "Weak but clear" c) "Roger, turn right, heading XXX" OR "Roger, turn left heading XXX." d) "Roger, out" This action establishes the PAR/final controller as accepting the responsibility for the remainder of the approach.

TABLE 3. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
5. (cont)	following for the radio check with: 1) a turn – "C/S, turn right heading XXX, over." or "C/S, turn left heading XXX, over."				
6.	2) Wheel check "Wheels should be down, over."	Radar contact has been established.	Wheel check must be given.		

4. Request the pattern controller to relinquish control of the communications frequency.

5. Establish radio contact with the pilot.

6. Transmit wheel check.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 3 must be achieved with the exception of enabling behavior 2, standard b, and enabling behavior 4. Allow the student three tries to pick-up the handoff as provided in the comment on pattern controller behavior.

Conditions – Conditions are provided in Table 3.

TERMINAL OBJECTIVE – Instruct the pilot to turn the aircraft onto the final approach course.

Discussion – When the aircraft enters the terminal area it typically is not lined up with the runway where it will land. The pattern controller controls the aircraft during most of the aircraft's approach. It is not until the very end of the approach that the final controller with his/her PAR system becomes involved. Ideally, the pattern controller has vectored the aircraft onto a course that will require only slight modification to get the aircraft onto the final course. The final controller instructs the pilot to turn to a new heading that will put the aircraft on a direct course to the landing area. The final controller is monitoring the azimuth portion of the PAR display. On this display the aircraft is represented as a radar pip (target) and the ideal course is represented by a horizontal line called the azimuth cursor. The azimuth cursor represents an imaginary linear extension of the runway's centerline. The final controller must vector the aircraft so that the target remains in contact with the azimuth cursor all the way to the landing area. The task is complicated by such factors as various wind conditions, good to poor handoffs from the pattern controller, the experience and skill of the

pilot, etc. The important skills that the final controller must acquire are the timing of the aircraft's turn onto final, so that the aircraft does not overshoot or undershoot the ideal course, and issuing the proper course heading to the pilot to assure that the aircraft remains in alignment with the ideal course throughout the approach. The situations listed above as complicating factors must be taken into account when the final controller is determining when to issue the turn and the heading required.

Enabling Behaviors – The enabling behaviors are described in detail in Table 4 and are listed below.

1. Time the issuance of the turn instruction to bring the aircraft directly onto the final course.

2. Instruct the pilot to turn the aircraft to a heading that will keep the aircraft on the final course.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 4 must be achieved.

Conditions – Conditions are provided in Table 4.

TABLE 4. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Time the issuance of the turn instructions to bring the aircraft directly onto the final course.	The handoff from the pattern controller has been completed. The target is approaching the azimuth cursor. Turn rate of the aircraft is the standard three degrees per second. The following factors impact the timing of the final turn. 1. Speed of the aircraft is: a) 90 kts b) 120 kts c) 140 kts d) 160 kts e) 200 kts 2. Skill level of the pilot is: a) optimum response b) average c) poor 3. Type of handoff, angle of incidence to the azimuth cursor. 4. Wind: speed and direction; Steady a) light & fluctuating b) 30° @ 10 kts c) 30° @ 20 kts d) 90° @ 10 kts e) 90° @ 20 kts Gusts a) none b) 30° ±20 kts c) 60° ±15 kts d) 90° ±10 kts	If the aircraft is at 1500 feet: a) the target must be within two target widths of the azimuth cursor at the six-mile mark. b) the azimuth cursor must intercept the target in zone one or two by the five mile mark.	Several smaller turns are preferable to one large turn because they allow the controller to gauge the pilot's responsiveness, etc.	

TABLE 4. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
2.	Instruct the pilot to turn the aircraft to a heading that will bring the aircraft onto the final course. The final controller uses: a) "C/S, Turn right, heading XXX, over" b) "C/S Turn left, heading XXX, over"	The target is approaching the azimuth cursor Wind: speed and direction Steady a) light & fluctuating b) 30° @ 10 kts c) 30° @ 20 kts d) 90° @ 10 kts e) 90° @ 20 kts Speed of the aircraft is: a) 90 kts b) 120 kts c) 140 kts d) 160 kts e) 200 kts	a) The heading issued must be the proper heading to keep the aircraft on course. b) Proper R/T must be used as described in Appendix A, phrase 6 or 7.	When the controller transmits a heading change to the pilot, the heading must include an allowance for the effect of the wind on the aircraft.	The turn to final is a very important turn since a turn that results in the aircraft directly on or at least touching the azimuth cursor will not require further course correction thereby increasing the efficiency of the approach.

TERMINAL OBJECTIVE – Provide initial reports to the pilot on the aircraft's position relative to interception with the glidepath.

Discussion – The proper performance of this task is critical to ensuring a smooth transition from level flight to a steady descent rate. Timing is of the essence. If these initial advisories are either late or early, the aircraft will be either above or below glidepath, and will consequently require additional corrective control. The experienced controller will take factors such as the pilot's reaction time and the aircraft's responsiveness into consideration in timing the advisories.

Enabling Behaviors – The enabling behaviors are described in Table 5 and are listed below.

1. Transmit the approaching glidepath advisory.
2. Instruct the pilot to begin descent.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 5 must be achieved except 2b.

Conditions – Conditions are provided in Table 5.

TERMINAL OBJECTIVE – Advise the pilot that from this point on he/she should not acknowledge any further transmission.

Discussion – This communication is made for a number of reasons. The first being convenience for both the pilot and the final controller. The convenience is also related to efficient performance of their respective tasks. The pilot is relieved of the necessity of responding to each of the controller's frequent communications thereby allowing the pilot to concentrate on manipulating the aircraft controls in a positive manner. The final controller, in turn, is relieved of the burden of prefacing each communication with the aircraft's call sign and suffixing each transmission with a termination phrase.

TABLE 5. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit the approaching glidepath advisory. The final controller uses: a) "C/S, approaching glidepath, over." OR b) "Approaching glidepath."	The target is approximately .95 miles from interception with the glidepath. The actual distance is within the range .25 to 1.67 miles from intersection depending on the speed of the aircraft. Aircraft speed is: a) 90 kts b) 120 kts c) 140 kts d) 160 kts e) 200 kts a) the final controller has *not transmitted* the do not acknowledge advisory. b) The final controller has transmitted the do not acknowledge advisory.	a) The advisory must be transmitted when the aircraft travelling at X_1 knots is between X_2 and X_3 miles from interception of the glidepath X_1 X_2 X_3 1) 90 0.25 0.75 2) 120 0.33 1.00 3) 140 0.30 1.16 4) 160 0.44 1.33 5) 200 0.55 1.67 b) Proper R/T must be used as described in Appendix A, phrases 26 or 27. c) The message must be transmitted once and only once during every approach.	A standard initial approach altitude is 1500 feet The preferred R/T sequence is: "C/S, approaching glidepath, over" --- "Do not acknowledge *further transmissions*" --- Filler transmissions must be added. --- "Begin descent" An acceptable R/T sequence is: "Do not acknowledge further transmissions" --- Filler transmissions must be added. --- "Approaching glidepath: --- *Filler transmissions* must be added. --- "Begin descent" ---	
2.	Instruct the pilot to begin descent. The final controller uses: "Begin descent"	The target intercepts the glidepath from below. If the target is at 1500 feet the target will be slightly below the glidepath at approximately 4 3/4 miles from touchdown.	a) The instructions must be issued 10-30 seconds following the approaching glidepath advisory. b) This advisory must precede any glidepath position advisories		The standard rate of descent is 750 feet per minute The typical lag time for jet aircraft is 2-4 seconds and 3-6 seconds for propeller aircraft.

TABLE 5. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
2	(cont'd)		c) The timing of the transmission of this advisory varies as a function of aircraft speed. In general the call is made when the glidepath cursor intercepts the upper 1/3 of the target. d) The message must be transmitted once and only once during every approach. e) Proper R/T must be used as described in Appendix A, phrase 28.		The glideslope is 3°; the touchdown point is 750 feet from the approach end of the runway.

By eliminating all of these unnecessary demands, both pilot and controller can concentrate on conducting a safe approach.

There is a price for this convenience however. In order to maintain contact and provide continuous feedback to the pilot the PAR controller must adopt a regular and continuous rate of transmission, at least one phrase every five seconds. The pilot in turn, must be aware of this requirement and must assume a loss of radio contact after five seconds of radio silence. If loss of radio contact occurs the pilot is obligated to execute a missed approach procedure.

Enabling Behavior – The enabling behaviors are described in Table 6 and are listed below:

1. Transmit the do not acknowledge further transmissions advisory.

2. Conduct a waveoff due to the final controller's failure to transmit at a continuous and regular rate.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 6 must be achieved.

Conditions – Conditions are provided in Table 6.

Precision Portion of PAR Approach

MISSION OBJECTIVE – Conduct the precision portion of a PAR approach through decision height.

Discussion – This portion of the final controller's job is the part that sets the PAR approaches apart as a very specialized form of approach. The controller has positive control of the aircraft during the PAR approach. It's important to note, that even though he is called a controller the only commands are turns to new headings. All other transmissions are

TABLE 6. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit the do not acknowledge advisory. The final controller uses: "C/S, do not acknowledge further transmissions."	The radio check has been transmitted. The wheel check has been transmitted. The begin descent advisory has not been transmitted by the final controller.	a) Radio contact must be established prior to transmitting this message. b) The wheels check call must be transmitted prior to this message. c) This message must be transmitted prior to transmitting the begin descent advisory. d) Proper R/T must be used as described in Appendix A, phrase 41.	This advisory may be transmitted prior to the approaching glidepath advisory but the preferred sequence is to transmit this advisory following the approaching glidepath advisory. Following the transmission of this advisory the final controller must transmit advisories and instructions at a minimum rate of one transmission every five seconds.	
2.	Conduct a waveoff due to the final controller's failure to transmit at a continuous and regular rate.	The do not acknowledge ... message has been issued. The pilot is executing a waveoff due to lost communications.	a) The final controller must transmit advisories at a regular and continuous rate. b) The rate of verbiage must not be faster than one second between phrases or slower than one phrase per five seconds. The average should be approximately one phrase per two seconds. c) If the pilot exercises the lost communications procedures, the final controller must handoff control of the aircraft to a pattern controller within seven seconds.	If the final controller does not maintain a regular and continuous rate of transmitting advisories, the pilot will take an automatic waveoff.	During the initial levels of training the transmission rate rule will be relaxed. When the pilot executes the automatic waveoff, the target on the PAR display will move up and off the screen.

only advisories! During the PAR approach the final controller issues advisories and turn commands that essentially control the aircraft's approach from prior to interception with the glidepath and course cursors of the PAR indicator to the culmination of the controlled approach when the aircraft is at decision height. There are several identifiable portions of the PAR approach that can be specified and expanded upon. These include azimuth control, glidepath control, and range calls. Each of these behaviors is specified in detail in the following sections.

Terminal Objectives – The precision portion of the PAR approach is comprised of the following terminal objectives:

a. Transmit course correction instructions to the pilot.

b. Advise the pilot of the aircraft's position and movements relative to the azimuth cursor.

c. Provide the pilot with information concerning the distance from the aircraft to touchdown.

d. Advise the pilot of the aircraft's position and movement relative to the glidepath cursor.

e. Request landing clearance from the tower and relay the wind and clearance advisories to the pilot.

f. Advise the pilot of a forthcoming break in the final controller's transmissions.

g. Provide the pilot with waveoff information for waveoff pertaining to clearance problems.

TERMINAL OBJECTIVE – Transmit course correction instructions to the pilot.

Discussion – The PAR controller is responsible for keeping the aircraft aligned with the runway centerline during the approach. To accomplish this the PAR controller transmits heading instructions for the pilot. The PAR

display contains an azimuth display that shows an imaginary extension of the runway centerline. This extension is referred to as the azimuth cursor. The goal of azimuth control is to keep the radar target in contact with the azimuth cursor for the duration of the approach. To accomplish this, the controller must issue heading commands that keep the aircraft aligned with the centerline extension.

Enabling Behavior – The enabling behavior is described in Table 7 and is listed below.

1. Transmit heading instructions to the pilot.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 7 must be achieved except 1c and 1f.

Conditions – Conditions are provided in Table 7.

TERMINAL OBJECTIVE – Advise the pilot on the aircraft's position and movement relative to the azimuth cursor.

Discussion – In addition to the heading instructions the PAR controller gives the pilot frequent feedback advisories concerning the target's position relative to the azimuth cursor and, in some instances, information about trends in the target's movement. Ultimately, the ideal approach will conclude with the aircraft lined up on the center of the runway. The ideal approach should avoid unnecessary course changes throughout the approach.

Enabling Behaviors – The enabling behaviors are described in Table 8 and are listed below.

1. Transmit azimuth position advisories.
2. Transmit an azimuth trend advisory to the pilot.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 8 must be achieved with the exception of enabling

TABLE 7. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit heading instructions to the pilot. The PAR controller uses: "Turn right heading XXX", or "Turn left heading XXX"	The target is moving along the azimuth display and the azimuth cursor does not intercept the target within zone one.	a) The extent or magnitude of the turn is constrained by the aircraft's distance from touchdown: 1) Further than five miles from touchdown the turn cannot be smaller than five degrees. 2) Within five miles, inclusive of five miles, the minimum turn is two degrees. b) When the aircraft is within five miles of touchdown and a heading advisory of greater than 120 degrees (± 60 degrees relative to the centerline) is transmitted, the student must recognize the mistake and make a counter-corrective turn within eight seconds. c) After the aircraft passes the five mile mark the target must remain in zones one or two for the rest of the approach. d) If the aircraft enters zone three after it passes the five-mile mark, the student has twenty seconds to vector the plane back into zone two. e) Proper R/T must be used as described in Appendix A, phrase 47 or 48.	The azimuth target is divided into zones as defined below: Zone 1: The azimuth cursor intercepts the exact middle of the target. Zone 2: The azimuth cursor intercepts the middle one-third of the target. Zone 3: The azimuth cursor intercepts the upper or lower one third of the target. Zone 4: The azimuth cursor has broken contact with the target. Graphic representation of the Zone Notation:  Determine the heading the aircraft should be on in order to intercept the azimuth cursor. Once the cursor has been intersected the aircraft must be revectored to remain in contact with the cursor.	The target must be in zone one or two for one-half mile or reach the five mile mark before zone three errors are recorded.

TABLE 7. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
1. (contd)			f) After the aircraft has passed the five mile mark, it should be in zone one for at least fifty percent of the remaining approach.	Wind will affect the azimuth portion of the approach by blowing the aircraft off course causing undershoot and overshoot of the course during turns. Wind factors should be taken into account when transmitting heading instructions.	

TABLE 8. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit azimuth position advisories: a) "Well right of course, turn left heading XXX." b) "Right of course, turn left heading XXX." c) "Slightly right of course" d) "On course" e) "Slightly left of course" f) "Left of course turn right, heading XXX." g) "Well left of course, turn right heading XXX." h) "Heading XXX." i) "C/S, heading XXX, over."	The radar target is moving along the azimuth display: a) right zone four b) right zone three c) right zone two d) zone 1 e) left zone two f) left zone three g) left zone four h) After "Do not acknowledge" when the monotony must be broken. i) Before "Do not acknowledge" when the monotony must be broken.	a) Well _____of course advisory requires a corrective turn within three seconds. b) Proper R/T must be used as described in Appendix A, phrase 25, 30, 31, 34, 35, 36, 50, 51, or 55. c) The heading given in h and i must be the same as the last heading given.	Zone notation from table 7. "Heading XXX" should not be transmitted more than five times per approach.	
2.	Transmit an azimuth trend advisory. a) "Well right of course, correcting." b) "Right of course, correcting." c) "Left of course, correcting." d) "Well left of course, correcting."	The target is moving toward the centerline. The target is in a) right zone four b) right zone three c) left zone three d) left zone four	a) Proper R/T must be used as described in Appendix A, phrases 32, 33, 53 or 54.	Zone notation from table 7.	

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behavior 1, standards b and c. Relax these standards to require eighty percent correct calls. The exception is due to the potentially large number of calls of this type that can occur during an approach.

Conditions – Conditions are provided in Table 8.

TERMINAL OBJECTIVE – Provide the pilot with information on the aircraft's distance to touchdown.

Discussion – Together with azimuth and elevation advisories, range data completes the precise positional information needed by the pilot to safely land the aircraft. The PAR controller is responsible for notifying the pilot at each mile while the aircraft is on final approach. Additionally, the controller informs the pilot when the aircraft reaches decision height: that point in the approach where the controller's responsibilities end and the pilot must decide whether or not to continue the approach.

Enabling Behavior – The enabling behaviors are described in Table 9 and are listed below.

1. Transmit range advisories to the pilot.
2. Advise the pilot when the aircraft reaches decision height.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 9 must be achieved, allowing one omission on 1b.

Conditions – Conditions are provided in Table 9.

TERMINAL OBJECTIVE – Advise the pilot on the aircraft's position and movement relative to the glidepath.

Discussion – Elevation information is the unique element in precision approach radar. Because of the limitations of ASR radar, ASR final control with regard to glidepath was limited to informing the pilot of recommended altitudes. This enabled the pilot to compare his rate of descent with that of

TABLE 9. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit range advisories to the pilot. The PAR controller uses: "X miles from touchdown" where x = 1 to 8	The leading edge of the target approaches a mile mark on the radar display.	a) An advisory at five miles from touchdown must be transmitted. b) Advisories prior to five miles are optional. But advisories at each mile are mandatory once any range advisory has been transmitted. c) The advisory must be issued ± 0.1 mile of the mile mark. d) Proper R/T must be used as described in Appendix A, phrase 37.		The display is logarithmic in range. The target decreases in size as it moves from right to left. The touchdown point is 750 feet from the approach end of the runway.
2.	Advise the pilot when the aircraft reaches decision height. The PAR controller uses: a) "At decision height." b) "At decision height, too X_1 for safe approach, if runway not in sight X_2" where X_1 = "high" "low" "far right" "far left" X_2 = "execute missed approach" (if the approach is a full-stop approach) or "climb and maintain 1500 feet, turn right heading 300" (for a low approach)	The target approaches the 3/4 mile mark and a) the target is touching both cursors, or b) the target is not touching one of the cursors.	a) The advisory must be issued not sooner than 0.85 miles from touchdown or later than 0.65 miles from touchdown. b) Proper R/T must be used as described in Appendix A, phrases 38 or 39. c) The advisory must be transmitted once and only once during each approach.	A late advisory is more serious than an early advisory. The controller's responsibility ends at this point. The decision height point is not marked on the display. The call is issued when the target reaches a point 1/4 inch to the left of the 1 mile mark.	

a predetermined glidepath (which provided the basis for determining recommended altitudes). This is not the case with a PAR final.

With PAR, the controller has the capability of observing the aircraft's rate of descent, and how this rate of descent compares with a predetermined glidepath. Now the pilot is constantly advised of his position in relation to glidepath, and of his relative movement (whether his aircraft is getting closer or further away from the glidepath).

Enabling Behaviors — The enabling behaviors are described in Table 10 and are listed below:

1. Issue glidepath position advisories.
2. Issue glidepath trend advisories.

Standards — In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 10 must be achieved with the exception of enabling behavior 1, standards a and c, and enabling behavior 2, standards a and b. Relax these standards to require eighty percent correct calls. These exceptions are due to the potentially large number of calls of this type that can occur during an approach. Also, the omission of one position and trend is permissible if a higher priority advisory must be given.

Conditions — Conditions are provided in Table 10.

TERMINAL OBJECTIVES — Request landing clearance from the tower and relay the wind and clearance advisories to the pilot.

Discussion — Requesting landing clearance from the tower and transmitting the clearance to the pilot are two behaviors that are critical to the safety of the aircraft. The tower retains responsibility for the landing sequence and hence the issuing of landing clearances. The PAR controller is actually just a relay device in the landing clearance system. Proper execution of this relay function ensures that the tower is aware of the aircraft's

TABLE 10. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Issue glidepath position advisories: a) "well above glidepath" b) "above glidepath" c) "slightly above glidepath" d) "on glidepath" e) "slightly below glidepath" f) "below glidepath" g) "well below glidepath"	The elevation cursor is beneath the target a) lower zone 4 The elevation cursor intercepts the leading edge of the target at: b) lower zone 3 c) lower zone 2 d) the glidepath cursor equally divides the target zone 1. e) upper zone 2 f) upper zone 3 The elevation cursor is above the target g) upper zone 4 See table 11.	a) Different position advisories can not be given without a trend advisory between them. b) Proper R/T must be used as described in appendix A, phrases 10 to 16. c) A position advisory must be made whenever the target changes zone unless the situation demands a higher priority advisory.	The glidepath target is divided into zones as defined below: Zone 1: glidepath cursor bisects the target. Zone 2: glidepath cursor intersects the upper or lower middle one third of the target. Zone 3: glidepath cursor intersects the upper or lower one third of the target. Zone 4: glidepath cursor has broken contact with the target. The graphic representation of the zone notation is the same as found in table 7, for the azimuth cursor.	The rate of descent changes between ± 250 feet per minute, based upon the advisories and aircraft speed. Priority scheme for transmitting temporarily conflicting advisories: 1. Mandatory missed approaches 2. Low altitude alert 3. Optional missed approach 4. At decision height 5. Headings 6. Trend and glidepath information 7. Range calls 8. Wind and clearance information
2.	Issue glidepath trend advisories: a. "coming up" b. "coming down" c. "going above glidepath" d. "going below glidepath"	The target changes zone as described above. a. The target is moving from upper zone 4 to upper zone 3; or from upper zone 3 to upper zone 2; or from upper zone 2 to on glidepath.	a) Trend advisories must not be issued successively. b) Trend advisories must be issued if and only if the target transitions from one zone to another.		

TABLE 10. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
2. (contd)	e. "going further above glidepath" f. "going further below glidepath"	b. The target is moving from lower zone 4 to lower zone 3; or from lower zone 3 to lower zone 2; or from lower zone 2 to on glidepath. c. The target is moving from on glidepath to lower zone 2. d. The target is moving from on glidepath to upper zone 2. e. The target is moving from lower zone 2 to lower zone 3, or from lower zone 3 to lower zone 4. f. The target is moving from upper zone 2 to upper zone 3; or from upper zone 3 to upper zone 4. See table 12.	c) Proper R/T must be used as described in appendix A phrases 17 to 24.		

TABLE 11. TARGET POSITION AND GLIDEPATH MESSAGE

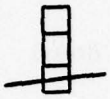
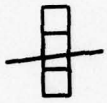
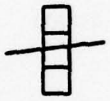
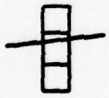
Magnified View of Aircraft Target and Intersecting Glidepath Cursor	Description of Position	Correct Glidepath Position Message
	Target above and not touching glidepath cursor.	Well above glidepath
	Glidepath cursor intersecting lower 1/3 of target.	Above glidepath
	Glidepath cursor intersecting lower half of middle 1/3 of target.	Slightly above glidepath
	Glidepath cursor bisecting leading edge of target.	On glidepath
	Glidepath cursor intersecting upper half of middle 1/3 of target.	Slightly below glidepath
	Glidepath cursor intersecting upper 1/3 of target.	Below glidepath
	Target below and not touching glidepath cursor.	Well below glidepath

TABLE 12. TABLE OF LEGAL TREND MESSAGES SPOKEN WHEN THE NEXT GLIDEPATH POSITION IS SPOKEN

Upward Trend	Next Glidepath Position Message	Downward Trend
No trend is legal		
Going further above glidepath	Well above glidepath	Coming down
Going further above glidepath	Above glidepath	Coming down
Going above glidepath	Slightly above glidepath	Coming down
Coming up	On glidepath	Going below glidepath
Coming up	Slightly below glidepath	Going further below glidepath
Coming up	Below glidepath	Going further below glidepath
	Well below glidepath	No trend is legal

current position and its intention to land. The relaying of the tower's clearance to the pilot informs him/her that access to the runway is unimpeded.

Enabling Behaviors – The enabling objectives are described in table 13 and are listed below.

1. Request landing clearance from the tower.
2. Relay the wind information and the landing clearance to the pilot.

TABLE 13. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Request landing clearance from the tower using the GCA Clearance Light System (the usual method): Depress the white-clearance request light.	The target is at the three ± 0. 1 mile or two ± 0. 1 mile range mark. The GCA Clearance light system is functional.	a) The clearance request must not be made prior to the target reaching the 3. 1 mile mark. b) All requests are made within a range of ± 0. 1 miles of the range marks. c) A request for landing clearance must be made at the 3 mile mark. d) If clearance to land is not received, a request must also be made at the two mile mark ± 0. 1 mile.		
2.	Relay the wind information and the landing clearance to the pilot. XXX at XX "Wind (direction and speed); cleared $\underline{X_1}$." X_1 = for low approach = for touch and go = to land	Wind information is displayed on the CRT. Wind direction is listed first followed by the speed in knots. The tower has issued landing clearance to the final controller to relay to the pilot.	a) The wind advisory is always transmitted before the pilot is advised of his clearance to land. b) The speed and direction of the wind must be correctly reported by the PAR controller. c) Both the wind and clearance advisories must be issued prior to the one mile mark if the clearance was received from the tower. d) After the tower has issued the landing clearance both the wind and clearance advisories must be transmitted in their entirety by the final controller.	The final controller must know the type of approach the pilot is executing.	Wind conditions fluctuate: a) no wind (light and variable) b) steady wind c) fluctuating wind speed d) wind direction fluctuates: - when barometric pressure is below 29. 92 inches of mercury and falling. The wind typically is from the southwest and fluctuates ± 20 degrees with periodic static conditions lasting up to one minute.

TABLE 13. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
2. (contd)			e) If the tower does not issue a landing clearance the final controller must not transmit a wind and clearance advisory to the pilot. f) Proper R/T must be used as described in Appendix A phrase 40.		- When the pressure is above 29.92 and rising the wind from the northwest may change direction as much as 10 degrees and the speed varies 10-25 kts.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 13 must be achieved, with allowance made on 2b for fluctuating wind conditions.

Conditions – Conditions are provided in Table 13.

TERMINAL OBJECTIVE – Advise the pilot of a forthcoming break in the final controller transmissions.

Discussion – The transmission break is a safety call that allows the pilot to report on situations that develop in the aircraft that may present a problem to the approach. At all other times during the approach subsequent to the do not acknowledge advisory, the controller's microphone is keyed cutting out the receiver and it is impossible to hear the pilot's transmissions.

Enabling Behaviors – The enabling behavior is described in Table 14 and is listed below.

1. Issue a break in the PAR controller's transmission series so that the pilot can advise the controller of any unusual situations aboard the aircraft.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 14 must be achieved, except 1c phrase 5 and 1d.

Conditions – Conditions are provided in Table 14.

TABLE 14. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Issue a break in the controller's transmission series so that the pilot can advise the controller of any unusual situations aboard the aircraft. The final controller responds: "Transmission break" and unkeys his microphone. Note: The controller must adjust his microphone and then ask the pilot if the quality of the transmission has improved. "How do you hear me now?"	The begin descent advisory has been transmitted. The target has not reached the one mile mark. Note: VU level reading has been very low. The pilot has responded "weak but clear".	a) The break must be issued when the aircraft is between one and five miles from touchdown. b) The controller must issue at least one transmission break during an approach. c) Proper R/T must be used as described in Appendix A phrases 42 and 5. d) If the pilot responds "weak but clear" the controller must respond.	Transmission breaks are issued to allow the pilot to report any adverse conditions, that may have developed during the approach. The controller is encouraged to simply unkey when no transmissions are required. The advisory "transmission break" need not be used every time.	The pilot will respond to the transmission break with "loud and clear" or "weak but clear" if the VU level is low.

TERMINAL OBJECTIVE – Provide the pilot with waveoff information for waveoffs pertaining to clearance problems.

Discussion – When the landing clearance is cancelled or is not received, the final controller must ensure that the aircraft executes a proper waveoff. In the basic training system three types of waveoff situations are included. These situations were chosen because together they form an element in the behavioral repertoire that every skilled controller must possess.

The automatic waveoff taken by the pilot when the transmission frequency rate rules are disregarded allows the training system to monitor the rhythm of the student and provide him with feedback when he departs from the standard. The PAR controller's job is to supply the pilot with a regular and continuous stream of information regarding his craft's approach to landing field. In light of this task and keeping in mind the job of the pilot, the final controller must not overburden the pilot with too much information or follow the other extreme, not giving the pilot enough information. The limits established for the transmission rate will allow the PAR controller to adjust his information rate to a medium between these two extremes.

The other two waveoff situations involve problems in either receiving a clearance or a cancellation of the clearance once it has been received. These situations are reasonably common and the student must be equipped to handle both after he/she leaves the NATTC program.

Enabling Behaviors – The enabling behaviors are described in Table 15 and are listed below.

1. Conduct a waveoff due to the lack of a landing clearance from the tower by the time the target reaches the one mile mark.

2. Conduct a waveoff due to the tower's cancellation of the landing clearance.

TABLE 15. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Conduct a waveoff due to the lack of a clearance from the tower by the time the target reaches the one mile mark. The final controller uses: a) "execute missed approach" b) "climb and maintain 1500 feet, turn right, heading 300."	The target is between one and two miles from touchdown. The tower has not issued a clearance for the aircraft to land. a) the aircraft is executing a full-stop approach. b) The aircraft is executing a low approach.	a) The waveoff must be issued so that the aircraft is beginning to climb out of the approach by the one mile mark. b) Proper R/T must be used as described in Appendix A, phrase 50 or 51.	The final controller must know the distance and hence time necessary for the aircraft to be climbing out of the approach by the one mile mark.	
2.	Conduct a waveoff due to the tower's cancellation of the landing clearance. The final controller responds: a) "execute missed approach" b) "climb and maintain 1500 feet, turn right, heading 300."	The tower will cancel the clearance in the following method: a) The tower clearance light system. The red cancellation light comes on. The audio signal pulses. The aircraft is executing a full-stop approach. b) The aircraft is executing a low approach.	a) The waveoff message must be transmitted within two seconds of receipt of the cancellation from the tower. b) Proper R/T must be used as described in Appendix A, phrase 50 or 51. c) The waveoff message must be transmitted if the tower cancels the landing clearance.		

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 15 must be achieved.

Conditions – Conditions are provided in Table 15.

Approach Termination

MISSION OBJECTIVE – Termination of the approach.

Discussion – When the aircraft reaches decision height the final controller's formal responsibilities have ended and the pilot resumes full responsibility. The remaining advisories that the final controller makes are courtesy calls that provide some measure of assurance to the pilot. The final controller advises the pilot when he is over the landing threshold which is the approach end of the runway, advises the pilot of the aircraft's azimuth position relative to the runway centerline and terminates the controlled approach. The type of approach determines the interactions necessary with the pattern controller. For full stop approaches, the final controller informs the pattern controller that the frequency is released to him indicating that the approach has terminated. In addition, the final controller should transmit rollout instructions to the pilot. For low approaches the final controller must notify the pattern controller that the approach is terminating and that a handoff will soon be made. In addition, the final controller must verify that the pattern controller has indeed taken control of the aircraft.

Terminal Objectives – The approach termination of the PAR approach is comprised of the following terminal objectives:

a. Advise the pilot when the aircraft is over the landing threshold and transmit a final course position advisory.

b. Provide the pilot and the pattern controller with termination of approach information.

c. Handoff control of the aircraft to the pattern controller.

TERMINAL OBJECTIVE – Provide the pilot with a final course position advisory and inform the pilot when the aircraft is over the landing threshold.

Discussion – These courtesy advisories are issued as a form of feedback and assurance to the pilot that his aircraft is still properly aligned for a safe landing. When the aircraft is over the approach end of the runway the pilot is informed that he is over the landing threshold, that is, he may land any time from this point on. This advisory is followed by an azimuth position advisory that informs the pilot of his craft's position relative to the runway centerline.

Enabling Behaviors – The enabling behaviors are described in Table 16 and are listed below.

1. Transmit the over landing threshold advisory informing the pilot that his craft is over the approach end of the runway.

2. Transmit the final course advisory informing the pilot of his craft's position relative to the runway centerline.

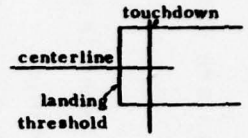
Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 16 must be achieved.

Conditions – Conditions are provided in Table 16.

TERMINAL OBJECTIVE – Provide the pilot with the termination of approach information.

Discussion – The PAR approach is formally terminated by the final controller transmitting "over" to the pilot. This is done prior to the aircraft's actual touchdown and no further advisories are transmitted while the aircraft is touching down. After the aircraft has landed the final controller instructs the pilot to contact the tower for taxi information.

TABLE 16. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit the over landing threshold advisory, informing the pilot that his craft is over the approach end of the runway. "Over landing threshold"	The final controller has transmitted the at decision height advisory. The target approaches and contacts the landing threshold marker.	a) The call must be transmitted within ± 1 second of the target contacting the landing threshold point. b) Proper R/T must be used as described in Appendix A phrase 43.	Landing threshold is 1/4 inch to the right of the touchdown reflection on the radar display.	During the initial phrases of training on this objective the landing threshold is marked on the PAR display, thusly:  After some practice the landing threshold markings are faded out until they disappear during the final phase of training.
2.	Transmit the final course advisory, informing the pilot of his craft's position relative to the runway centerline: a) "on course" or no response b) "slightly right of course" c) "slightly left of course"	The final controller has issued the over landing threshold advisory. a) The target is bisected by the azimuth cursor. b) The right side of the middle one third of the target is intersected by the azimuth cursor. c) The left side of the middle one third of the target is intersected by the azimuth cursor.	a) The message must follow the landing threshold advisory immediately. b) Proper R/T must be used as described in Appendix A, phrase 34, 35, or 36.		

Enabling Behaviors – The enabling behaviors are described in Table 17 and are listed below.

1. Inform the pilot that the controlled approach is being terminated.
2. Transmit the rollout instructions to the pilot.
3. Release the radio frequency to the pattern controller.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 17 must be achieved.

Conditions – Conditions are provided in Table 17.

TERMINAL OBJECTIVE – Handoff control of the aircraft to the pattern controller.

Discussion – The final controller must handoff control of the aircraft to the pattern controller in two situations. The first is the routine situation where the pilot has completed a low approach and the aircraft is leaving the landing area. The second situation is an emergency situation where the aircraft has been waved off of its approach for one reason or another. As in the initial handoff to the final controller, the sequence of events is quite rigid to assure complete information transmission. The first event is the final controller warning the pattern controller that the final controller intends to make a handoff. This is followed by the handoff proper and the additional task of verifying that the pattern controller has indeed assumed control of the aircraft. The verification task is critical to the safety of the aircraft and to the safety of other aircraft in the area, for an uncontrolled aircraft can create problems in the terminal area. In fact, an uncontrolled aircraft in the terminal area is an illegal situation. There are situations where the aircraft is not completely controlled and the final controller must be aware of these. They all involve voluntary waveoff by the pilot and the final controller must be cautioned to recognize the situation when it occurs and to immediately coordinate the waveoff with the pattern controller. The most

TABLE 17. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Inform the pilot that the controlled approach is being terminated. The final controllers response is "Over."	The target has passed the landing threshold. Both the landing threshold and the final course advisory have been transmitted.	a) Both the landing threshold and the final course advisories must precede the termination message b) Proper R/T must be used, as described in Appendix A, phrase 44.	The PAR approach has been completed. Over landing threshold, the course advisory and Over are transmitted with only very brief pauses between them.	The pilot responds to the termination message with: "Roger."
2.	Transmit the roll-out instructions to the pilot. The final controller says: "Contact tower after landing, over."	The control of the approach has been terminated. The aircraft has landed.	a) Rollout instructions must be issued on all full-stop approaches. b) Rollout instructions are issued only on full-stop approaches. c) The final controller must wait at least twenty seconds following "over" to transmit the rollout instructions. d) Proper R/T must be used as described in Appendix A, phrase 45.	The controller waits 20 seconds to issue the rollout instructions so that he does not interrupt the pilot during the actual landing of the aircraft.	The pilot responds to the rollout instructions with: "Roger."
3.	Release the radio frequency to the pattern controller. The final controller uses: "Button X, clear." and deselects the radio frequency transmit button.	The rollout instructions have been issued.	a) The final controller must release the radio frequency to the pattern controller within ten seconds of issuing the rollout instructions. b) Proper R/T must be used as described in Appendix A, phrase 46. c) The final controller must release the radio frequency transmit button after every approach.		

common reason for the pilot taking a voluntary waveoff is a situation where the final controller does not transmit at continuous and regular five second intervals.

Enabling Behaviors – The enabling behaviors are described in Table 18 and are listed below.

1. Handoff control of the aircraft to the pattern controller.

2. Verify that the pattern controller has accepted responsibility for the control of the aircraft.

Standards – In order to establish that the student can perform this terminal objective effectively, all standards for the associated enabling behaviors listed in Table 18 must be achieved.

Conditions – Conditions are provided in Table 18.

Advanced Training

MISSION OBJECTIVE – The enrichment program.

Discussion – There are a variety of situations which lie beyond the scope of the basic GCA-PAR training curriculum, but can be addressed in an advanced training curriculum. The purpose of this enrichment program is to provide the faster students with the opportunity to experience situations in the simulator that they most likely will encounter in the fleet as emergencies.

The approach taken in designing the enrichment curriculum was to identify the situations that impact the task of the PAR controller in some nontrivial way and select a representative subset of these situations to incorporate into the curriculum. The situations we have identified as appropriate enrichment exercises are listed below as terminal objectives.

TABLE 18. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Handoff control of the aircraft to the pattern controller by transmitting: a) "On the go, C/S, button X." and releasing the transmit button when the pattern controller has acknowledged the handoff. b) "Missed approach, C/S, map position, Button X."	The approach has been terminated. a) A low approach is being terminated. b) A waveoff has occurred and the aircraft is executing a missed approach.	a) The handoff must be made each time a waveoff or low approach termination occurs. b) The handoff must be made within thirty seconds of the aircraft passing the landing threshold on low approaches or of the issuance of missed approach instructions. c) Proper R/T must be used as described in Appendix A, phrase 9 or 29. d) The C/S and button number must be correct in the PAR controller's message. e) Range is given in condition b) to the nearest one half mile.		The pattern controller verifies the handoff by selecting his monitor button for the particular frequency being used. If the handoff is not issued within thirty seconds of the aircraft's passing landing threshold, the pattern controller responds: "Position X, where is C/S."
2.	Verify that the pattern controller has accepted responsibility for the control of the aircraft.	The final controller has issued the handoff message. The final controller has released the transmit button and depressed the monitor button. The pattern controller has released the monitor button and selected the transmit button.	a) The final controller must continue monitoring the frequency until the pattern controller transmits "C/S, RADAR Contact."		

Terminal objectives – The advanced training of the PAR curriculum is comprised of the following terminal objectives:

a. Control the aircraft's azimuth during a no-gyro approach.

b. Conduct waveoffs due to emergency situations.

c. Transmit a low altitude alert.

TERMINAL OBJECTIVE – Control the aircraft's azimuth during a no-gyro approach.

Discussion – The final controller's role in control of the aircraft's azimuth under emergency conditions is critical in the conduct of a safe approach. When the pilot informs the controller that his compass is not functional, a no-gyro approach must be conducted. The controller must also be prepared to identify situations that warrant a no-gyro approach. During a no-gyro approach, the controller tells the pilot when to start the turns and when to stop the turns.

Enabling Behaviors – The enabling behaviors are described in Table 19 and are listed below.

1. Warn the pilot that his/her aircraft is not performing the assigned course correction.

2. Inform the pilot that the approach will be conducted as a no-gyro PAR approach.

3. Transmit the one half standard rate turns advisory.

4. Transmit no-gyro course correction advisories.

TABLE 19. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Warn the pilot that his aircraft is not performing the assigned course correction. The final controller uses: a) "C/S, heading XXX over." b) "Heading XXX"	a) "Do not acknowledge . . ." has not been transmitted. b) "Do not acknowledge . . ." has been transmitted.	The warning must be issued if more than one quarter mile elapses after a turn is issued and less than a two degree change in the target's course is observed. Proper R/T must be used as described in Appendix A phrase 25 or 55.	Unresponsive turns indicate compass failure in the aircraft.	Always use a good pilot for no-gyro approaches. 25% of all approaches in the enrichment curriculum are no-gyro approaches 90% of the no-gyro approaches are stated as such at the handoff The pilot responds to the warning with: "Roger"
2.	Inform the pilot that the approach will be conducted as a no-gyro PAR approach. The final controller uses: a) "C/S, this will be a no-gyro PAR approach, over." b) "This will be a no-gyro PAR approach."	The pilot has been warned of heading deviations. The aircraft did not respond properly to the heading instruction. a) "Do not acknowledge . . ." has not been transmitted. b) "Do not acknowledge . . ." has been transmitted. Ten percent of all no-gyro approaches are initiated by the final controller	Following the warning, the pilot has one half mile to correct the aircraft's course. If the correction is not made the final controller must announce that the approach will be a no-gyro approach. The final controller must announce the no-gyro approach within the interval of one half to three quarters mile from the point where the warning was issued to the pilot. Proper R/T must be used as described in Appendix C phrase 1 and 2. When the pattern controller announces a no-gyro approach in the handoff the final controller must conduct a no-gyro approach.		

TABLE 19. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES (Cont).

No.	Behavior	Conditions	Standards	Knowledge	Comment
3.	Transmit the one half standard rate turns advisory. The PAR controller uses: "Make one half standard turns."	The aircraft has begun descent. The no-gyro approach has been announced to the pilot.	The message must be made after the aircraft has begun descent. The message must be transmitted only once during the approach. Proper R/T must be used as described in Appendix C phrase 3.	The standard rate of turn is 3° per second.	
4.	Transmit no-gyro course correction advisories. The final controller uses: a) "C/S, turn right, over." b) "C/S, turn left, over." c) "C/S stop turn" d) "Turn right" e) "Turn left" f) "Stop turn"	The no-gyro PAR approach has been announced to the pilot. Do not acknowledge advisory has not been transmitted. a) The target is to the left of the azimuth cursor. b) The target is to the right of the azimuth cursor. c) The target is approaching the azimuth cursor. Do not acknowledge, advisory has been given. d) The target is to the left of the azimuth cursor. e) The target is to the right of the azimuth cursor. f) The target is approaching the azimuth cursor.	Same as table 7. Proper R/T must be used as described in Appendix C phrase 4, 5, 6, 7, 8 or 9.	Same as table 7.	

TERMINAL OBJECTIVE – Conduct waveoffs due to emergency situations.

Discussion – Waveoff situations require that the controller must add to his perceptual/cognitive/response repertoire. Therefore these situations require the definition of enabling objectives, etc.

The waveoff situations occur when the pilot or the controller make an error or series of errors that result in the aircraft exceeding limits commonly associated with aircraft safety.

Enabling Behaviors – The enabling behavior is described in Table 20 and is listed below.

1. Conduct an emergency waveoff

TERMINAL OBJECTIVE – Transmit a low altitude alert.

Discussion – The low altitude alert is the last situation we will include that makes a specific addition to the PAR/final controller's response repertoire. A low altitude alert is an advisory that is issued by the PAR/final controller when the aircraft descends too far below the glidepath for a safe approach.

Enabling Behavior – The enabling behavior is described in Table 21 and is listed below.

1. Transmit a low altitude alert.

TABLE 20. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Conduct an emergency wave-off PAR controller uses: a) "Radar contact lost, if runway not in sight climb and maintain 3000, turn right, proceed direct point bravo, hold until advised by GCA, over." b) "Radar contact lost, climb and maintain 3000, turn right, proceed direct point bravo, hold until advised by GCA, over." c) "Execute missed approach." d) "Climb and maintain 3000, turn right, heading 270."	A. Target disappears from the azimuth portion of the display. a) Clearance has been relayed. b) Clearance has not been relayed. B. Targets encroach within three miles of one another. a) A full stop approach is being executed. b) A low approach is being executed. C. Target moves in a very erratic manner, specifically the target moves from one well zone to another within three seconds. a) Same as B above.	1) When display failure occurs the next transmission must be the wave-off. 2) The student must not allow the target to move off of the display without transmitting a wave-off. 3) Proper R/T must be used as described in Appendix C phrase 10 or 11. 4) The proper phrase must be used under the appropriate conditions. a) The targets may get no closer than 2.8 miles from one another. b) Proper R/T must be used as described in Appendix C phrase 12 or 14. 1) The student must transmit the waveoff within ten seconds of the target entering the second well zone. 2) Proper R/T must be used as described in Appendix C phrase 12 or 14. c) The target may not be more than one target width below the glidepath cursor for each mile from touchdown.		

TABLE 21. SPECIFIC BEHAVIORAL LEARNING OBJECTIVES

No.	Behavior	Conditions	Standards	Knowledge	Comment
1.	Transmit a low altitude alert. The PAR controller uses: "Low altitude alert, check your altitude immediately."	a) The target loses altitude at such a rate that the ratio of target widths below glidepath to miles from touchdown is greater than one.	a) Whenever the ratio is greater than one the low altitude alert advisory must be transmitted. b) The advisory must be transmitted within five seconds of the ratio exceeding one to one. c) Proper R/T must be used as described in Appendix C phrase 13.		

Section III

AUTOMATED ADAPTIVE TRAINING IN THE GCA-CTS

General

The behavioral objectives with their associated standards define the cognitive, verbal and motor skills which the trainee should acquire in GCA controller training. The course syllabus or curriculum outline shows the ways in which the knowledge will be conveyed and skill development will be encouraged by the GCA-CTS. The standards associated with each skill provide the vehicle by which the training is automatically adapted to the student's needs. Although each step must be completed, the rate of progress is dependent upon the rate at which the criteria for advancement are met. Thus the training system adapts to the student's individual needs. In certain cases, remedial training is provided for those students for whom the standard instruction is insufficient.

Syllabus Development

The principles which guided the syllabus development are:

a. The student must understand what is expected, and must be given challenging but attainable short-term goals.

b. The complex GCA control task is composed of simple elements.

c. The order of topic presentation should be such that existing skills are reinforced.

d. Practice is essential and the amount of practice provided should be adaptively tailored to the student's needs.

e. The student should not be allowed to practice and therefore, reinforce incorrect behaviors.

f. The integration of new skills with acquired skills is a learning objective that must attend new skill acquisition.

The underlying training philosophy of the GCA-CTS is that since each simple component element of the GCA task is mastered and then integrated with existing skills before the next simple component is addressed, the complex skill described as GCA control will develop naturally and efficiently. An example will illustrate this point. Students enter the GCA school after having just learned surveillance radar procedures and R/T. It is natural to build on the course vectoring skill acquired in the previous phase of instruction while learning to interpret the new PAR display. Therefore azimuth control is one of the first problems presented by the GCA-CTS. One of the most important aspects of azimuth control is the turn to final. If this turn is timed properly, the necessity for course corrections on final is greatly reduced and the quality of the approach is improved. The GCA-CTS therefore gives the student the opportunity to concentrate on this problem under a variety of circumstances until a certain level of proficiency is attained. It is clear that this skill can be acquired more efficiently under these conditions than could be expected when this behavior is practiced only once per approach.

The overriding concern in the development of all aspects of the GCA-CTS, and particularly in the syllabus has been and will be user acceptance. Sophisticated training techniques are not enough to ensure an effective training system because the student's motivation is a critical ingredient in his learning success. Therefore in addition to inspiring the student through challenging problems, the system must avoid undermining his motivation by recalcitrance, particularly in the area of speech recognition. Since it is easy to learn to talk in such a way that speech recognition is facilitated (namely naturally), this instruction is designed into the syllabus. When recognition errors do occur and replay is requested, the audio tape recording of the student's voice will usually reveal the cause.

In general, user acceptance will be secured by good feedback. When the student performs well he will be commended. If his performance is imperfect, feedback will be available as to the precise nature of the errors and corrective measures will be provided. Thus there will be no mystery surrounding the systems's evaluations, and positive suggestions for improvement will be available.

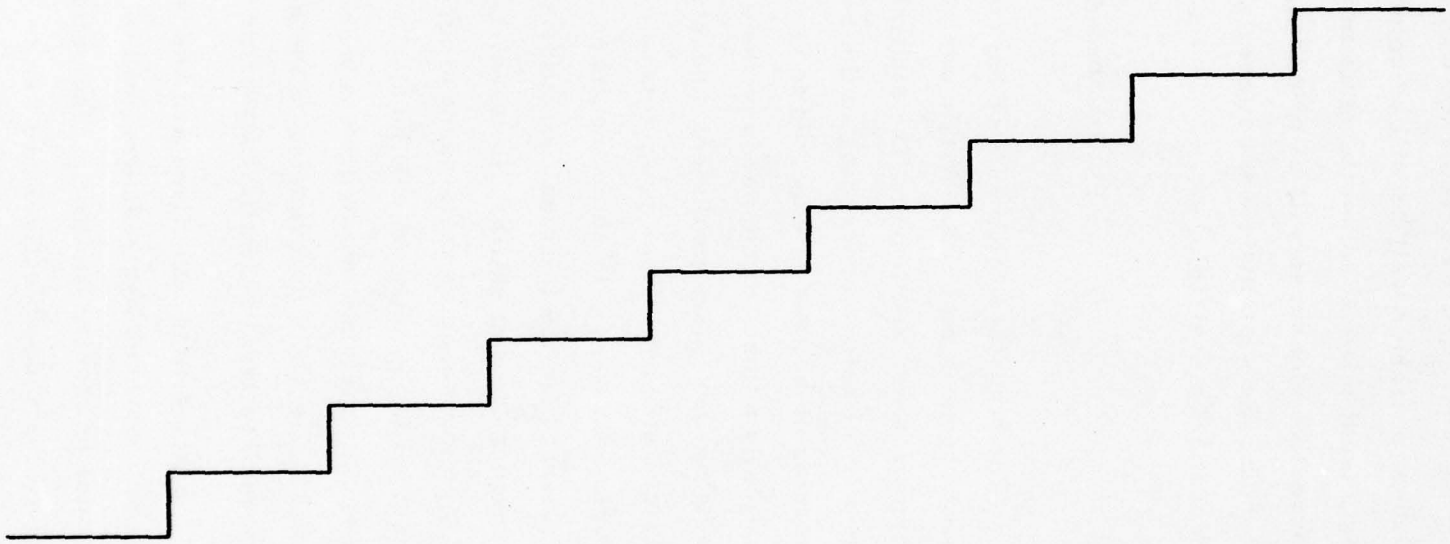
Syllabus Architecture

The structural elements of the course syllabus are the levels of achievement shown in Table 22. Within each level of achievement, several learning objectives are identified. The student will complete each learning objective for a level before proceeding to the next level. The time taken to meet the learning objectives is expected to vary with each student. The system automatically adjusts to the needs of the student and provides as much practice as he needs. More proficient students advance more quickly through the various steps than less proficient students, but all must attain the same level of mastery. In some instances, the criterion for advancement is more stringent than the terminal objective standard to produce over training of infrequently used skills. However, in general, standards for performance will be increased as the student progresses so that the overall proficiency required for graduation will be attained gradually and systematically. Adjusting proficiency requirements will allow the student to refine the lower level skills while progressing to the higher levels. The student will reach the desired level of proficiency prior to receiving enrichment training.

The learning objectives are addressed individually in the syllabus. A phased approach has been designed to convey the information and to allow the trainee to acquire the skill. The salient features of the phases are similar for all learning objectives and can be described generally. The system begins by introducing the topic, explaining its importance (often with the aid of

TABLE 22. LEVELS OF ACHIEVEMENT

Level One	Level Two	Level Three	Level Four	Level Five	Level Six	Level Seven	Level Eight	Level Nine
•Overview	•Align Azimuth	•Course position Advisory	•Align Elevation	•Transmission Break	•Make Handoff to Pattern Contoller	•Performance Test	•Enrichment Training	•Enrichment Training
•Model Controller	•Turn to Final	•Range Marks	•Begin Descent	•5-second Rule	•Accept Handoff from Pattern Controller		•Servoing	•Emergencies
•Levels of Achievement	•Corrections on Final	•Clearance/ Wind	•Approaching G/P	•Over Landing Threshold	•Wheels down Check			
•Phases	•Turn to Final (with Wind)	•Decision Height	•Do not Acknowledge	•Terminate Approach				
•Intro to Voice	•Corrections on Final (with Wind)	•Waveoff	•C/P Advisories	•Rollout Instructions				
•Digits								



written materials) and demonstrating the skill. Three phases of instruction follow. Phase I is dedicated to teaching the student the required R/T. In this phase, the student practices the verbal behavior and the system learns to recognize the student's voice. Prompts, typical displays and other learning aids are provided. When the student has learned the R/T and the system has suitable voice reference patterns (VRPs), Phase II begins. In Phase II, the system observes as the new procedure is practiced. The task may be a purely synthetic game related to some aspect of the GCA task, or it may be a realistic GCA problem. In either case, when a mistake is made involving the new material, the system will freeze and correct it. Thus the student will not have the opportunity to practice incorrect behaviors. The interrupted exercise will then proceed or be restarted as appropriate. When the new skill is established to the degree required by the associated criterion, Phase III begins. In this phase, the newly acquired skill is practiced and integrated with previously acquired skills. No system freezes are initiated, rather the system observes and grades the performance. After these runs, an optional replay will be available, and the student will be given feedback on his performance. When proficiency is attained in Phase III and a minimum number of practice runs have been completed, the next topic is presented.

Remedial Training

Remedial training will take place according to the type of task (knowledge or skill) and the level of achievement the student is at when he/she develops a problem.

The training system will detect student errors and keep track of them. An acceptable number of errors, as shown in figure (2), can be made and graded. However, if this number is exceeded, remedial training will be required.

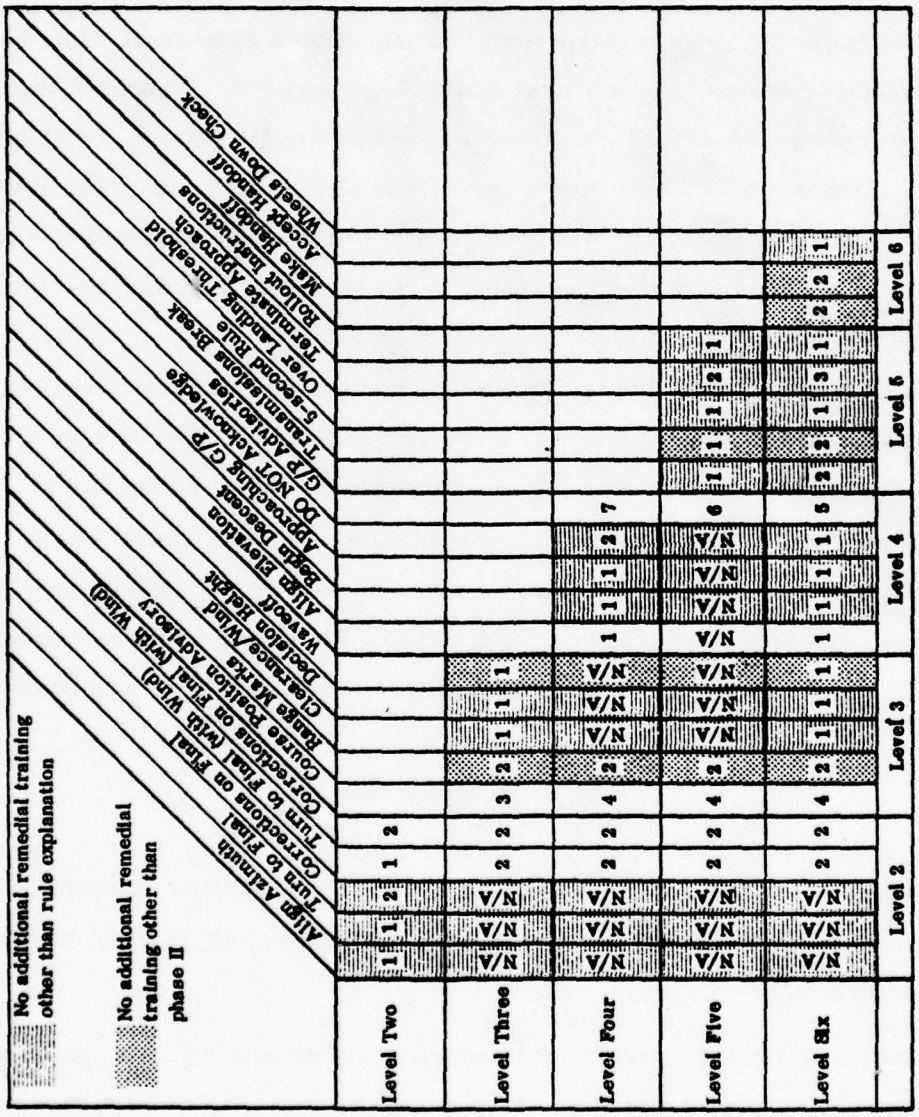


Figure 2. Acceptable Error Levels

Before any remedial training is given the system will determine if the errors were from not understanding the voice. Voice training and revalidation will be given if needed. After voice problems are resolved (if any) and if remedial training is still dictated, the training system will determine the classification of remedial training required. Three areas are recognized: knowledge, simple skill task, and complex skill task.

KNOWLEDGE – This category includes single transmissions and simple tasks. When errors are made on these items, the system assumes the student overlooked them rather than lacked the skill to perform them. Knowledge tasks are:

a. Align Azimuth
b. Turn to final (no wind)
c. Corrections on final (no wind)
d. Clearance/wind
e. Decision height
f. Begin descent
g. Approaching glidepath
h. Do not acknowledge
i. Transmission break
j. Over landing threshold
k. Terminate approach
l. Rollout instructions
m. Wheels down check

Rule presentation, placement, phraseology or correct procedures will be presented to remind the student to perform the task at the appropriate time.

SIMPLE SKILL TASKS – These tasks require a moderate level of skill. The applicable rules are not complex. Simple tasks are:

a. Waveoff
b. Make handoff
c. Accept handoff
d. Range marks
e. 5-second rule

Phase II training in the previous level where the material was introduced will be used for simple skill remedial training. The student will review only the material related to the errors and after completion will return to the current level.

COMPLEX SKILLS – These are tasks that require rhythm, timing and coordination. Complex skill tasks are:

a. Turn to final (with wind)
b. Corrections on final (with wind)
c. Course position advisories
d. Servo elevation/azimuth combination
e. Glidepath advisories

The complex skill areas will have separate remedial exercises designed to better develop the needed skill. Realizing the initial training was insufficient for this student, a new approach will be used to present the same material.

GCA-CTS Levels of Achievement

The levels of achievement are described in detail in the following paragraphs and tables. In the tables, the column labeled Task provides a numbering system for problems within a level. The reference column shows the

number of the behavioral objective to which the task is related. The other columns are self explanatory.

LEVEL 1 – The purpose of Level 1 is to introduce the student to the PAR radar, to the means by which he will learn the PAR approach procedures in the GCA-CTS, and to the proper use of the training system. An overview will be provided with the aid of textual materials and some verbal discussion by the GCA-CTS. A demonstration PAR approach will be conducted by the system to show the student what he will be able to do when he completes the course and to inculcate a professional attitude in the performance of the task. The specific levels of achievement will be described so that the student will have a general idea about the way in which he can develop his skills. Finally, he will learn to use the voice system effectively, by learning microphone placement, use of the VU meter, and by practicing with a limited vocabulary consisting of the digits zero through nine. This practice will at the same time teach him to interpret headings on the PAR azimuth display. Learning to use the speech system and the development of confidence in the system's ability to recognize the spoken word takes only a brief period and is critical for ensuring the good speech recognition which will ultimately secure user acceptance. The topics are described in Table 23.

LEVEL 2 – Level 2 gives the student his introduction to a problem in PAR control, namely azimuth control. The student learned the R/T required to effect course corrections during his ASR experience and learned to interpret headings on the PAR display in Level 1. In this level, he will learn to effect a timely turn to final and also to vector the aircraft on final under calm and windy conditions. Azimuth radar servo control is also introduced. Topic presentation is shown in Table 24.

LEVEL 3 – In Level 3 the student configures the voice system to recognize course position advisories, range calls, the decision height advisory, clearance and wind, and the execute missed approach instruction as shown in

TABLE 23. LEVEL 1 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T1.1		Overview	None	An overview of how the voice system works. Allow the trainee (T/E) to interact with the system.	Observe overview interact with training system using joystick.	Indoctrination	None, however T/E may elect to review			
T1.2		Demonstrate what student will be able to achieve (model controller)		An overview of what the controller will be able to do when he completes the learning objectives.	Observe model controller and interact with training system	To present the big picture of what will be expected of the student.	None, however T/E may elect to review.			
T1.3		Describe how the levels of achievement work		Introduce the levels of achievement and how the learning objectives will be attained.	Observe how the system will present learning objectives. Interact with training system.	To present how T/E will be able to accomplish the task.	None, however T/E may elect to review.			
T1.4		Describe breakdown of levels into phases		Introduce the method of teaching new material. Phase I, II, III.	Observe phases and interact with training system.	To show step-by-step how material will be taught.	None, however T/E may elect to review.			
T1.5		Introduction to voice		Introduce how the voice system will work with the student.	Observe and interact with training system.	To present the voice system.	None, however T/E may elect to review.			
T1.6		Placement of microphone, VU meter levels		Introduce the student to talking to the training system	Interact with training system voicing the digit as required.	To ensure proper placement of microphone, to collect voice patterns for the digits.	10 repetitions of each digit.			
T1.7		Learn to talk to the speech recognition system.	Digits 0-9	Ask student to count, pausing between digits. Echo when digit is understood else "?". Expect repeat after "?". After 5 "?" ask student to go on	Count, 0-9 pausing between digits. Repeat digit if "?" appears	Validate digit VRPs	5 perfect counts 0-9 in 6 tries.			

TABLE 24. LEVEL 2 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T2.1	Table 1	Learn to use azimuth servo.		Explain the purpose of alignment and how to request alignments.	Lower the azimuth radar to pick up the centerline reflector.	Ensure azimuth is properly aligned.	Student servos down using the joystick			OPNAVINST 3721.1H acceptability of the radar is a controller/ ATC supervisor determination which cannot be usurped by noncontroller personnel.
T2.2	Table 1	Check alignment of the azimuth cursor with respect to the centerline reflector.		Student servos down and determines if antenna alignment is needed	Select "align" if needed.		Determine if alignment is needed 5 of 5 times.			The controller must be aware other controllers use the same radar and should avoid moving the antenna except to keep the A/C on the scope.
T2.3	Table 1			Explain how lowering and raising the azimuth antenna will cause an A/C to fade from the scope if not in the beam.	Raise the antenna to a point which is high enough to reduce excessive ground clutter yet still enable the controller to observe the centerline reflector.	Get the azimuth antenna back to the proper angle.	Raise the azimuth antenna up to paint incoming A/C 4 of 5 times.	Servo in direction of target.		
T2.4	Table 2	Servo to maintain A/C on the azimuth display.		Allow practice on A/C fading (going above or below according to where beam is) Phases I, II, III. See figure 3.	Servo azimuth to maintain target within radar limits	Keep the A/C in the azimuth beam.	Servo 4 of 5 times in proper direction to find and maintain A/C within 5 seconds.			
T2.5		Speak headings with appropriate stylization	digits	Explain stylization requirement for heading digits. Explain	Respond to questions using appropriate stylization.	Practice with heading stylization	90% recognition accuracy per digit			

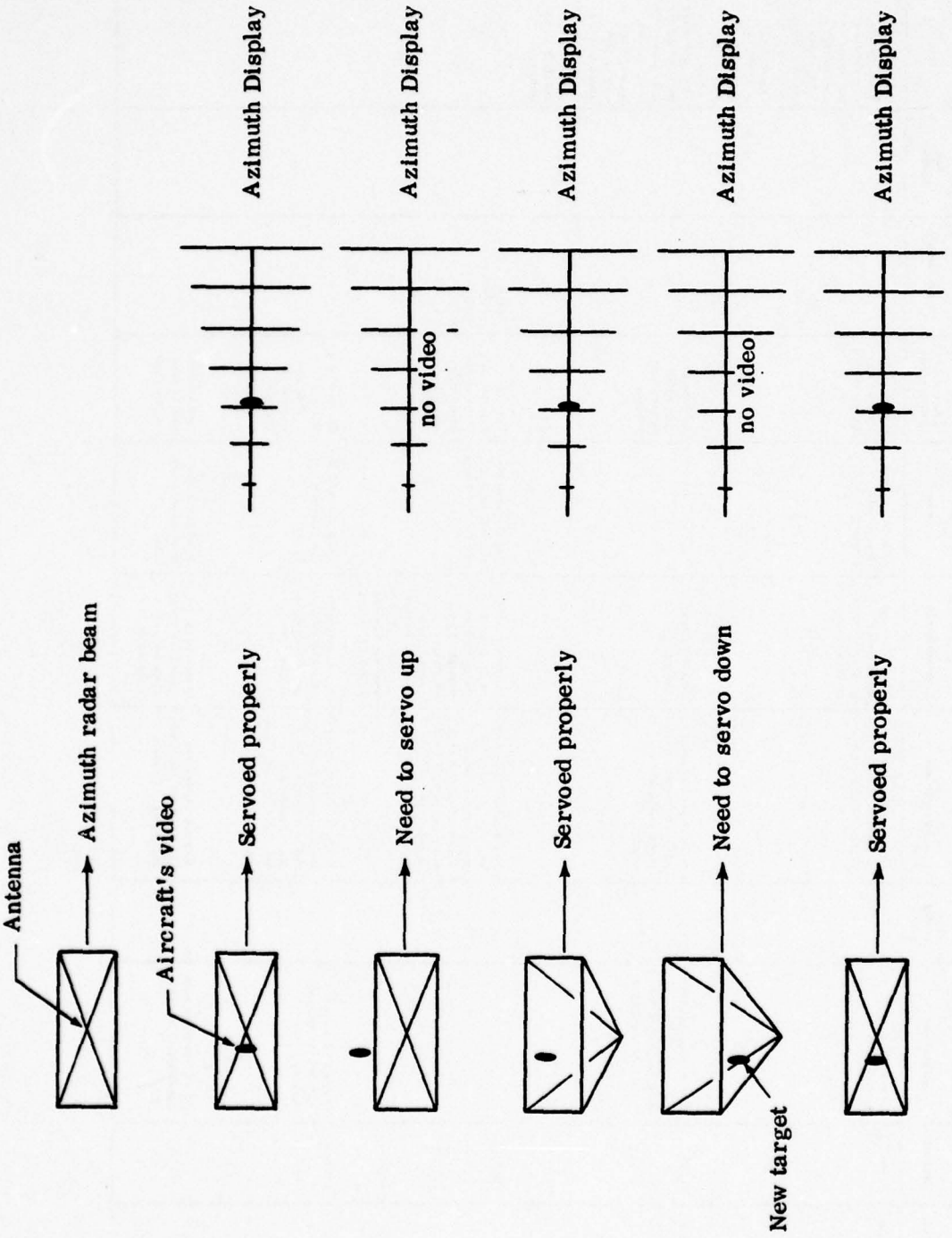


Figure 3. Azimuth Servo

TABLE 24. LEVEL 2 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T2.5 (cont)				this task. Pose questions involving compass rose. Manual *return to exercise* above if desired.			after 15 headings.			
T2.6	Tables 4 and 7	Interpret heading on PAR azimuth display using target trail; no wind.		Explain azimuth portion of display. Pose questions involving PAR azimuth display echo responses, correct errors. (Use only one runway heading.) Introduce target trails.	Respond to questions using appropriate stylization. Interpret target heading using target trails.	Learn to interpret azimuth display, more stylization practice	After 5 consecutive correct responses, interpret 13 of 15 headings within 3°.			
T2.7		Learn stylization of turn commands, turn right heading (TRH) and turn left heading (TLH).	TRH, TLH	Explain stylization requirement for TRH, and TLH. Give student practice verbalizing. Collect VRPs. Validate with game.	Practice TRH and TLH commands. Repeat advisories as instructed.	To teach TRH and TLH and stylization.	5 valid TRH 5 valid TLH with no errors			
T2.8	Table 4	Turn to final, no wind.		Explain importance of task. Explain technique. Prompt then score final turn only, (do not show entire run). Prompting, scoring. Shade in target area about the cursor (fade out with practice).	Practice turns to final as required, from left and right of course.	Interpret when to turn to final, validate, TLH, TRH	Give turn to final to cause A/C to be parallel to course with target touching azimuth under various conditions, 10 times of 12.			
T2.9	Table 7	Determine appropriate time for heading corrections.		Introduction. Phases I, II, III: maze game using turn right heading XXX, then left heading XXX (ballistics game same phrases) combination game. See figure 4.	Detect when a turn should be issued, press button.	Learn timing of course corrections.	Select time of corrections within 3 seconds 12 times of 15.	Breaking contact, not parallel.		
T2.10	Table 7	Interpret zone positions on the aircraft video		Explain and display the zones in the video	Identify zones as associated	Interpret the proper position of video.	Correctly identify			

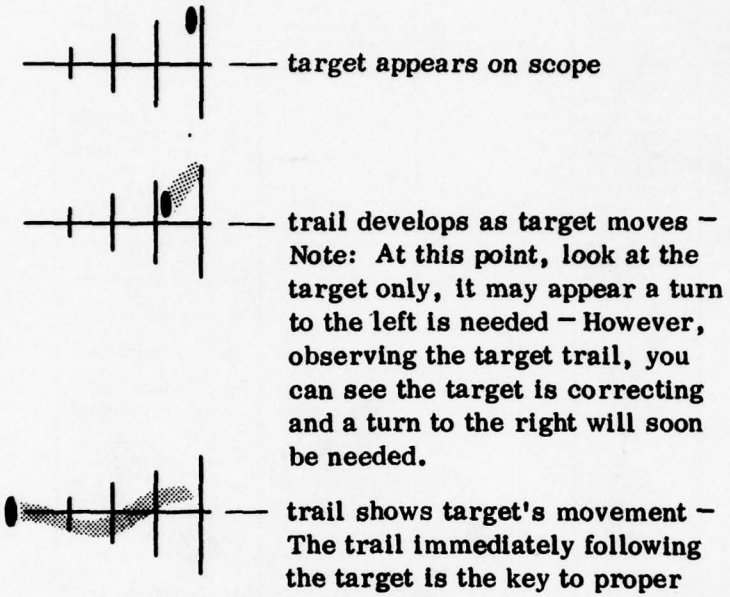


Figure 4. Target Trail

TABLE 24. LEVEL 2 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T2.10 (cont)				and allow the student to practice identifying the different zones.	with video sectioning.		positions 8 times out of 10.			
T2.11	Table 7	Transmit heading corrections, no wind.		Introduction. Phases I, II, III: Azimuth display.	Issue course corrections 1) outside 5 miles make corrections minimum of 5° increments, 2) within 5 miles, 2° minimum, 3) within 5 miles the A/C must be in zone 1, 50% of the time, 4) if A/C goes into zone 3, T/E has 20 secs. to correct	Learn to vector on final.	Target paralleling and touching cursor 50% of time in last 5 miles, at least 10 tries. 1) 9 of 10 2) 9 of 10 3) 5 of 10 4) 7 of 10	Correction should be 5° for each target width off center. Initiate turn when target breaks contact with cursor, or when target is not paralleling cursor.	7110.65 Section 17-120[3]a. Issue course guidance and inform the aircraft when it is on course frequently. Inform the aircraft of any deviation from course.	
T2.12	Table 4	Turn to final with cross winds.		Present technique for for countering wind. Phases I, II, III. Various wind conditions. Direction: 10° - 90° relative, fluctuating, speed 10 - 30 kts., 50% fluctuation.	Same as without wind.	Learn turning to final taking wind into consideration.	Require A/C parallel course, target touching azimuth under various conditions 10 times of 12.	Wind 10 kts 30° 20 kts 30° 10 kts 90° 20 kts 90° Crab 5° optional 5° 5° 10°		
T2.13	Table 7	Transmit heading corrections with wind.		Present technique for crabbing. Phase I, II, III. Various wind conditions. Direction: 10° - 90° relative, fluctuating; speed 10 - 30 kts., 50% fluctuation.	Same as without wind.	Learn corrections on final taking wind into consideration.	Target paralleling and touching cursor 50% of time in last 5 miles, at least 10 times. 10 trials with random wind: 1) correct for wind 2) correct for wind 3) 5 of 10 4) 9 of 10	Wind 10 kts 30° 20 kts 30° 10 kts 90° 20 kts 90° Crab 5° optional 5° 5° 10°		

Table 25. Again, most of this R/T is already familiar from his ASR experience. What must be learned here is to interpret the PAR radar display in order to apply the skills he has previously mastered. In addition, he will learn to divide the target and interpret target position with respect to the azimuth cursor. Before advancing to the next level, he will be given practice runs in which he will be required to use all the procedures learned to date. In completing Level 3, he will essentially be doing ASR approaches (with minor R/T differences) using the PAR radar. His new skills are being built gradually while his existing skills are being reinforced.

LEVEL 4 – In Level 4, the student is introduced to the glidepath radar including servoing, and learns to use the glidepath R/T, as shown in Table 26. The range call instruction in Level 3 provides the bridge to the new topic of the glidepath radar display since the target is shown on glidepath though not described in detail in conjunction with that instruction. Here the display is described more thoroughly. The presentation of the glidepath position and trend advisories is carefully designed to minimize the difficulties associated with learning this R/T. Again, before proceeding to the next level, the new skills are integrated with the old through practice runs, and the student is encouraged to conform to the thumb rule of giving approximately three times as many glidepath as course messages.

LEVEL 5 – The controller's responsibility terminates at the point at which the decision height message is issued. Nonetheless, advisories are issued until the aircraft has reached landing threshold or has executed a missed approach. In this level, the student must learn to notify the pilot when he has reached landing threshold, and to give course position immediately after the over landing threshold advisory. In addition, the student will learn to reduce the interval between radio transmissions to not more than five seconds and to develop a rhythmic pattern of verbalization. Prior to this level, the emphasis will have been on accuracy and the rapid issuance of messages will have been discouraged. Table 27 shows the phases of instruction.

TABLE 25. LEVEL 3 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T3.1	Table 8	Transmit the course advisory informing the pilot of his craft's position relative to the runway centerline A/C on or right of course.	OC, SRC, RC	Introduce • On course (OC) • Slightly right of course (SRC) • Right of course (RC) Phases I, II, III; synthetic problems only in phase III. See figure 5.	Transmit course advisories	Inform the A/C of position with respect to centerline.	Select correct course position 5 of 5 times.	OC and SRC doesn't have to be given. If RC then correcting or TLH---, RC.	7110.065-1211C	Target trail practice
T3.2	Table 8	As in 3.1, A/C left of course.	SLC, LC	Introduce • Slightly left of course (SLC) • Left of course (LC). Phases I, II, III, synthetic problems only in Phase II. See figure 6.	Transmit course advisories.	Inform A/C of position with respect to centerline.	Select correct position 10 of 10 times from all learned to date.	If LC then correcting or TRH---, LC.		
T3.3	Table 3	Transmit other course position messages.	Well right/left of course; correcting.	Introduce other course advisories valid prior to decision height. Phases I, II, III. See figure 7.	Learn to use course R/T, and course trend advisory "correcting".	Complete the student's course message repertoire.	Distinguish course well zone 5 of 5 times in synthetic problems. Transmit "correcting" at the correct time 5 times of 5 in synthetic problems.			
T3.4	Table 8	Transmit range to touchdown	Range mark advisories	Present mile marker on hash marks, explain importance of calling range marks collect VRPs. Phases I, II, III; using both azimuth and glidepath displays. In phase III, require heading corrections as well.	Responding to prompts, learn to transmit the range to touchdown while the video is touching the hash mark.	To issue range mark while giving heading corrections with wind.	After VRPs have been collected in 10 trials, all range calls must be given, and timing must be within tolerance 8 of 10 times.	The 5 mile call is mandatory. After any range call, all subsequent range calls must be given. The advisory must be issued ±0.1 mile of the mile mark; this is accomplished	7110.65 Section 17-1204. Inform the aircraft of its distance from touchdown at least once each mile on final approach. Phraseology: (number	

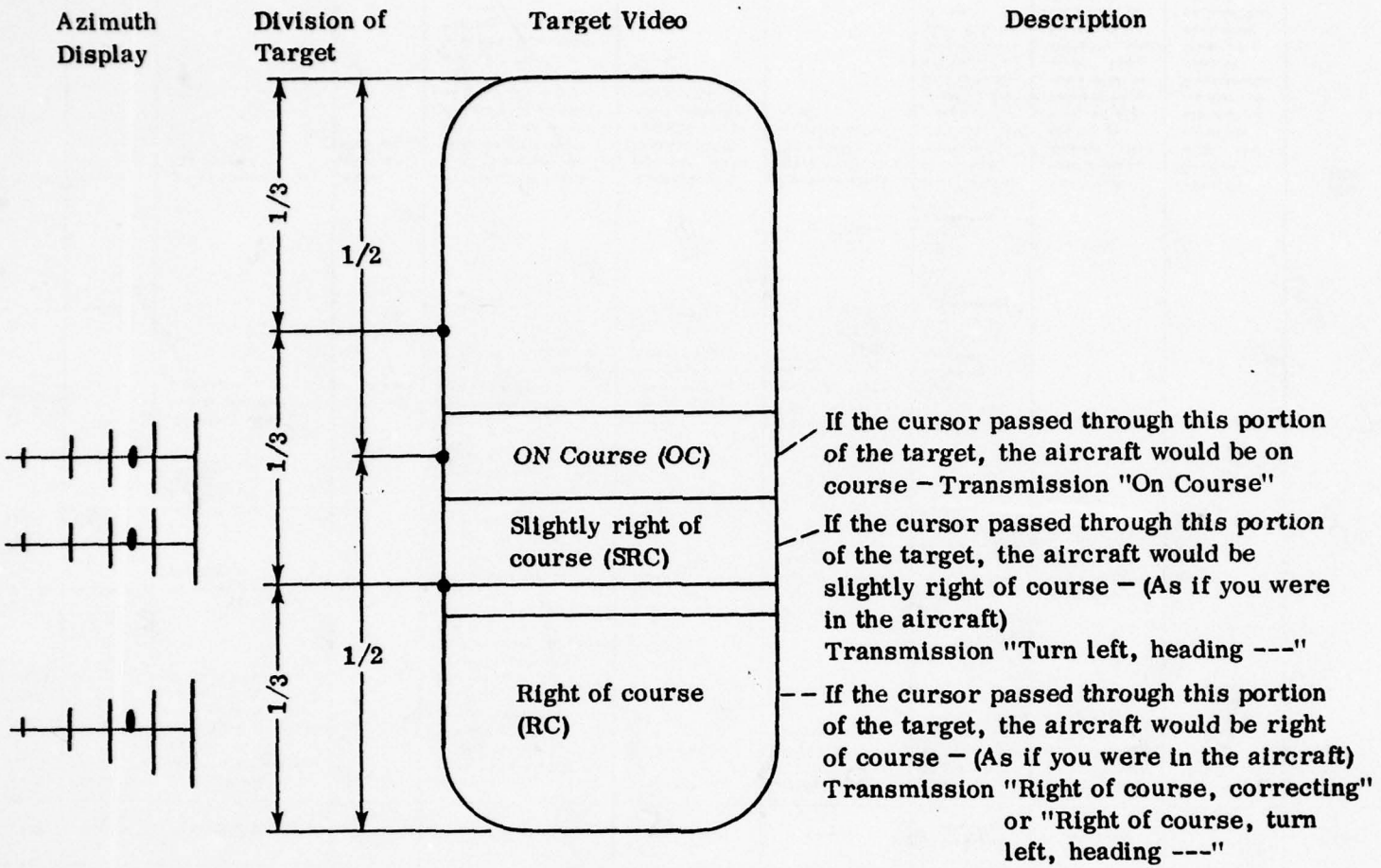


Figure 5. Expanded Azimuth Target Aids

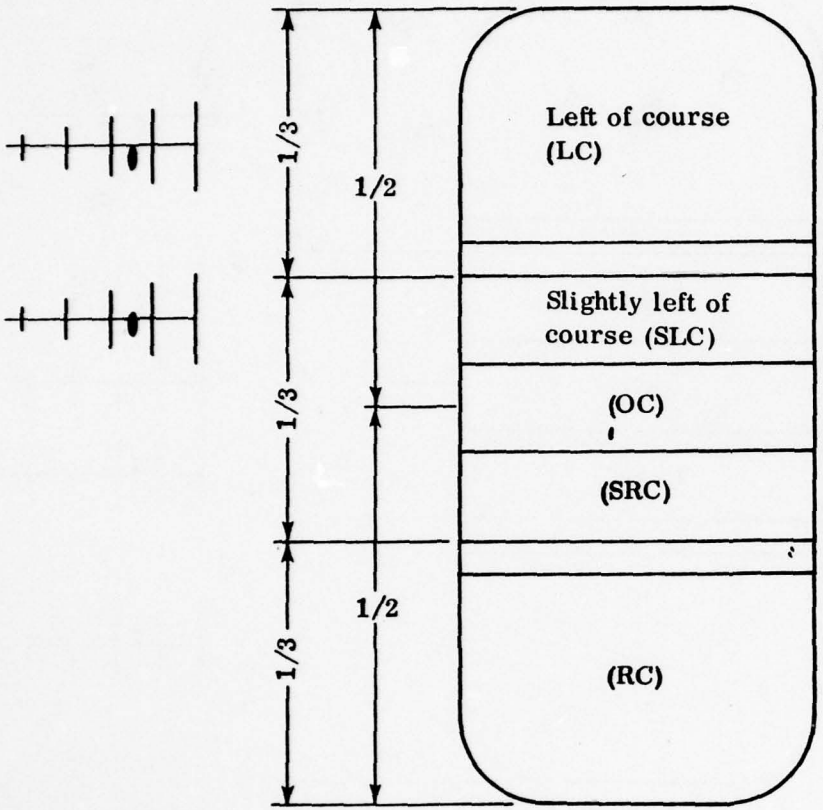


Figure 6. Expanded Azimuth Target Video

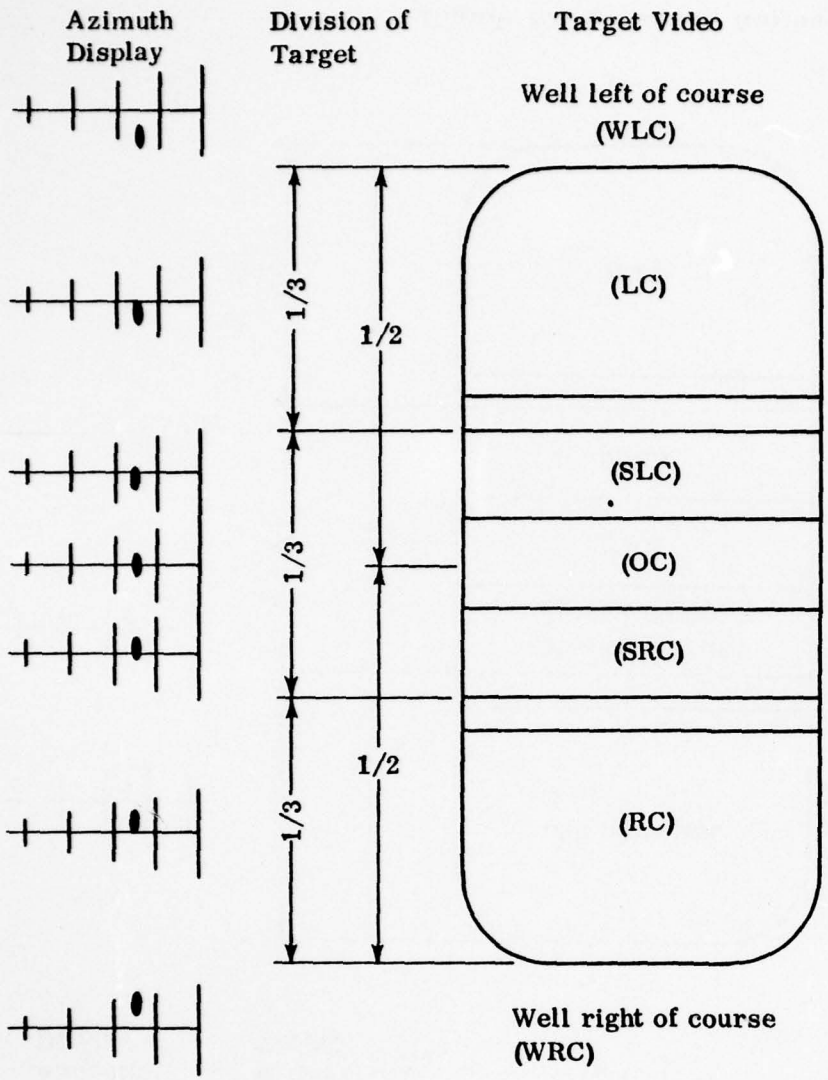


Figure 7. Expanded Azimuth Target Video

TABLE 25. LEVEL 3 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T. 3. 4 (cont)								if the call is given when the leading edge of the video is touching the hash mark.	of miles) miles from touchdown.	
T3. 5	Table 13	Request clearance		Present procedures for obtaining clearance. Give clearance randomly when requested, once out of 20 less than 2 miles. Phases I, II, III.	Request clearance at three miles. Request a second time, if not received, by two miles.	To request clearance for landing.	While conducting azimuth approaches request clearance 5 out of 5 times.			
T3. 6	Table 13	Issue wind and clearance	Wind, clearance.	Demonstrate transmitting wind and clearance after received, collect VRPs. Phase I, II, III.	Transmit wind and clearance to A/C after receiving clearance to land.	To transmit wind and clearance to A/C.	While conducting azimuth approaches transmit wind and clearance 5 out of 5 times after clearance is received.		7110. 65 Section 7-1020. Issue landing clearance. Phraseology cleared to land. Issue surface wind and landing clearance Phraseology wind (direction/velocity) cleared to land.	
T3. 7	Table 9	Transmit at Decision Height	At decision height	Present proper transition and when to make it, collect VRPs.	Transmit at decision height.	To allow the A/C to transition from instrument to visual environment.	While conducting azimuth approaches. Transmit at decision height on time in 9 out of 10 trials.	Decision Height point is 1/4 in to the left of the one mile hash mark.	7110. 65 Section 17-1210. Inform the aircraft when it reaches the published decision height Phraseology: at Decision Height	

TABLE 25. LEVEL 3 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Visual Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T3.8	Table 6	Transmit waveoff or missed approach option	Execute missed approach. If runway not in sight execute missed approach clearance not issued; Clearance cancelled.	Present situations that require issuance of the missed approach and missed approach option.	Learn R/T, recognize and respond to conditions requiring issuance of waveoff or waveoff option.	To waveoff aircraft approach or to give option.	Issue appropriate waveoff 9 out of 10 times.	Issue missed approach option ("If runway not in sight") if 1) target transits from one "well" zone to the other on either cursor within 3 seconds, or 2) if target breaks contact with either cursor at decision height. Issue waveoff with reason if a) clearance is not received by 1 mile or b) clearance is cancelled.	7110.65 1174-Final approach abnormalities. 1195 Approach Guidance Termination 7110.65 1195 a(2). In your opinion, continuation of a safe approach to the MAP is questionable.	

TABLE 26. LEVEL 4 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T4.1	Tables 1 and 2	Check and request the alignment of the elevation cursor and mile marks if needed.		Demonstrate how to check and request the alignment. Phases I, II, III.	Request adjustment for elevation cursor with respect to the touchdown reflector, if needed.	To ensure proper alignment of the elevation antenna and mile marks.	Select align when needed correctly 4 of 5 tries.			
T4.2		Servo to maintain radar contact.		Demonstrate how to servo to maintain radar contact. • servo azimuth antenna to center the two mile mark on the elevation cursor at the start of each period. If target is high on the elevation display servo up, if low, servo down. • servo elevation antenna in the direction the target is in relation to centerline (as if you were in the aircraft). • See figure 8. • Allow practice AZ/EL problems • Phase I, II, III.	Servo to find or maintain radar contact.	To keep the aircraft in the beam of the AZ and EL radars.	Servo to find aircraft and maintain in the beam 4 of 5 times servoing in proper direction within 5 seconds to find the aircraft.	Servo in direction the target is in relation to centerline (as if you were in the A/C).		
T4.3	Table 5	Instruct pilot to begin descent.	Begin descent.	Introduction. Phases I, II, III.	Instruct pilot to Begin descent at the appropriate times.	Train student when to issue "Begin descent".	Given while video is intercepting the elevation cursor in the top 1/3 portion of the target's video, 5 of 5 tries.	Issue advisory when target intersects glidepath from below. Jet aircraft require 2-4 seconds lead time, prop aircraft 3-6 seconds. The object is to time the advisory so that the A/C will be in the on glidepath zone.	7110.65 Section 17-1202. When an aircraft reaches the point where final descent is to start, instruct it to begin descent. Phraseology: Begin Descent	

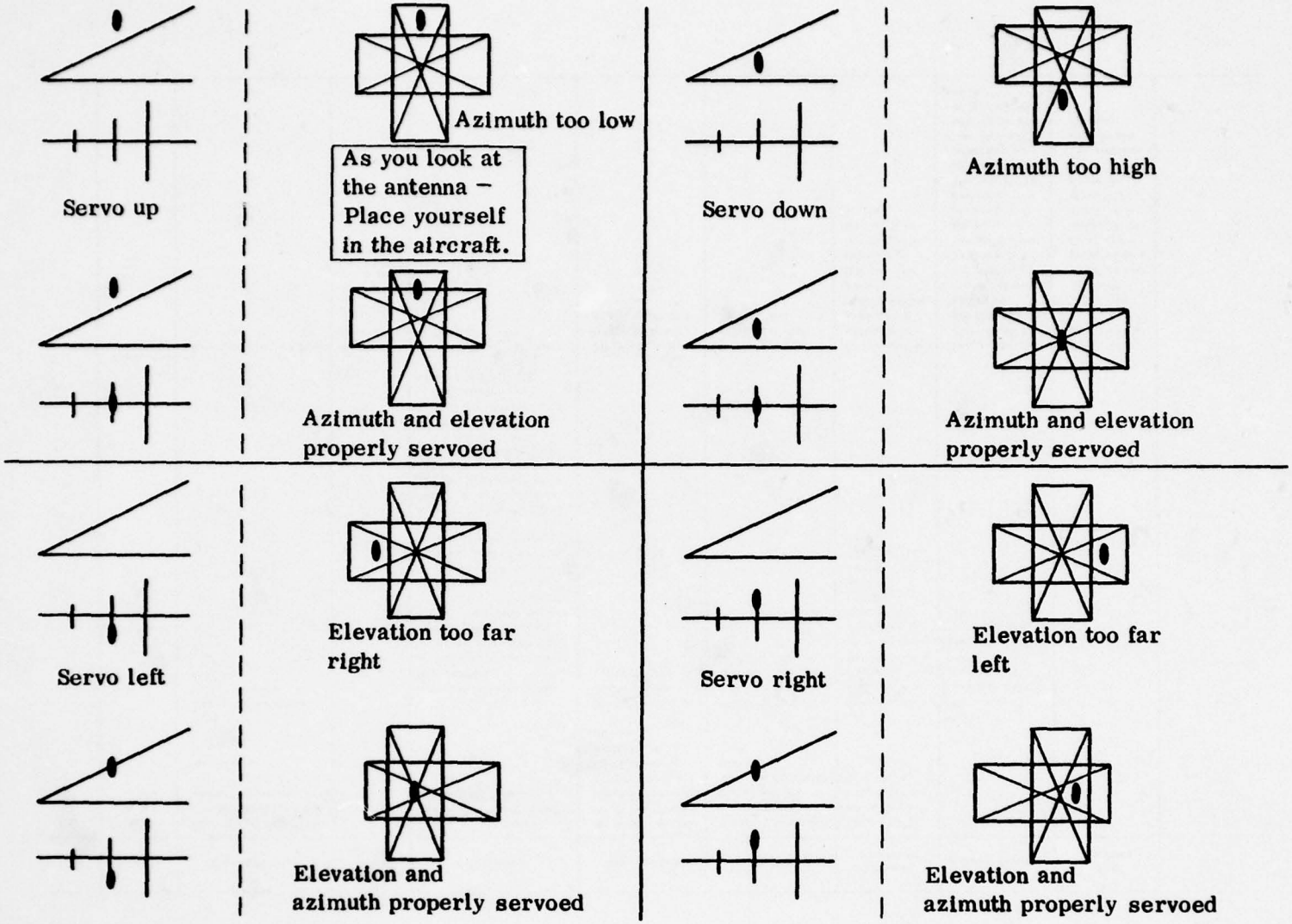


Figure 8. Elevation/Azimuth Servo

TABLE 26. LEVEL 4 OF THE GCA-CTS SYLLABUS (Cont.)

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T4.4	Table 5	Issue approaching glidepath advisory	Approaching glidepath	Introduction Phases I, II, III.	Issue "Approaching glidepath"	Alert pilot that within 10-30 seconds the A/C will be instructed to begin descent.	Given within 10-30 seconds 5 of 5 times.	The instruction must be issued 10-30 seconds prior to the begin descent instruction.	7110.65 Section 7-1700, Inform the aircraft when it is approaching glidepath (approximately 10-30 seconds before final descent) Phraseology: "approaching glidepath"	A standard initial approach altitude is 1500 feet.
T4.5	Tables 3 and 6	Advise the pilot that from this point on the pilot should not acknowledge each transmission from the final controller.	Do not acknowledge further transmission.	Introduce the transmissions and show proper timing. Phase I, II, III.	Transmit Do not acknowledge further transmissions. After wheels check message and prior to begin descent advisory. Ensure radio check is held prior to Transmission.	To let the pilot know the controller will have a steady key unless otherwise designated.	While conducting a PAR approach issue "Do not acknowledge further transmission" at least 4 of 5 tries.	Do not acknowledge advisory must be given prior to begin descent. Preferred timing is 5 seconds prior to begin descent.	7110-65-1164. After contact has been established with the final controller and while on the final approach course, instruct the aircraft not to acknowledge further transmissions. Phraseology: "Do not acknowledge further transmission". 1152-Lost Communications	
T4.6	Table 10	Issue glidepath advisories	BGP, CU, SBGP, OG, GBGP, GFBG, WBGP	Introduce glidepath 1. position advisories: • below glidepath (BGP) • slightly below glidepath (SBGP)	Issue position (WBGP, BGP, SBGP, and OG) and trend (CU, GBGP, and GFBG) advisories.	To introduce and train glidepath advisories emphasizing proper trend between position advisories.	Of course and glidepath messages, transmit not more than 50% nor less than 20% course msgs.	Different position advisories can not be given without a trend advisory between them. Position	7110.65-1203. Inform the aircraft when it is on glidepath and frequently	If in doubt orders first (azimuth) then advisories (elevation) with safety having priority

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TABLE 26. LEVEL 4 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T4.6 cont				• on glidepath (OG) • well below glidepath (WBGP) 2. trend advisories • coming up (CU) • going below glidepath (GBGP) • going further below glidepath (GFBG) 3. introduce 3:1 rule, 3 glidepath advisories to one azimuth, however consider priorities. At completion tell student how they did in relation to 3:1 rule 4. Display prompt on display explaining it will be used only until R/T is smooth. 5. Phases I, II, III. 6. See Figure 9.				advisories must be made in order. A position advisory must be made whenever the targets' position changes zones. Trend advisories must not be issued successively. The advisories should not lag behind the target's true position.	inform the aircraft of any deviation from glidepath.	
T4.7	Table 10	Issue glidepath advisories	SAGP, GAGP, CD	Introduce glidepath • position advisories: slightly above glidepath (SAGP) • trend advisories: going above glidepath (GAGP) and coming down (CD). Phases I, II, III. • See figure 10.	Issue position (OG and SAGP, SBGP, BGP, and WBGP) and trend (GAGP, CD, CU, GBGP, and GFBG) advisories	To train glidepath advisories	Transmit proper position and trend position 4 of 5 times. Of course and position messages, transmit not more than 45% nor less than 25% course messages.	In case of doubt, call the position closest to GP.	7110.65-1203	

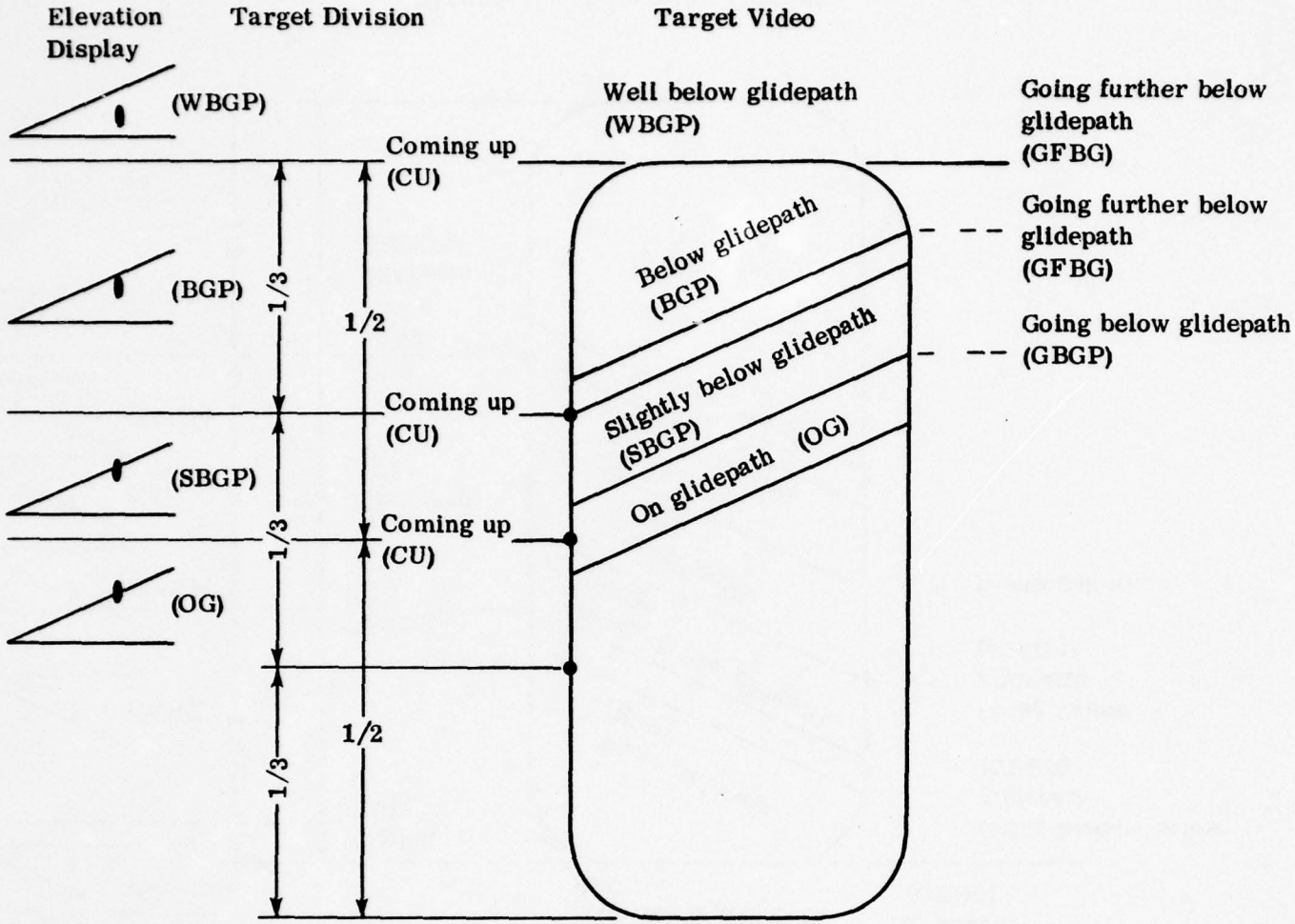

Figure 9. Elevation Display

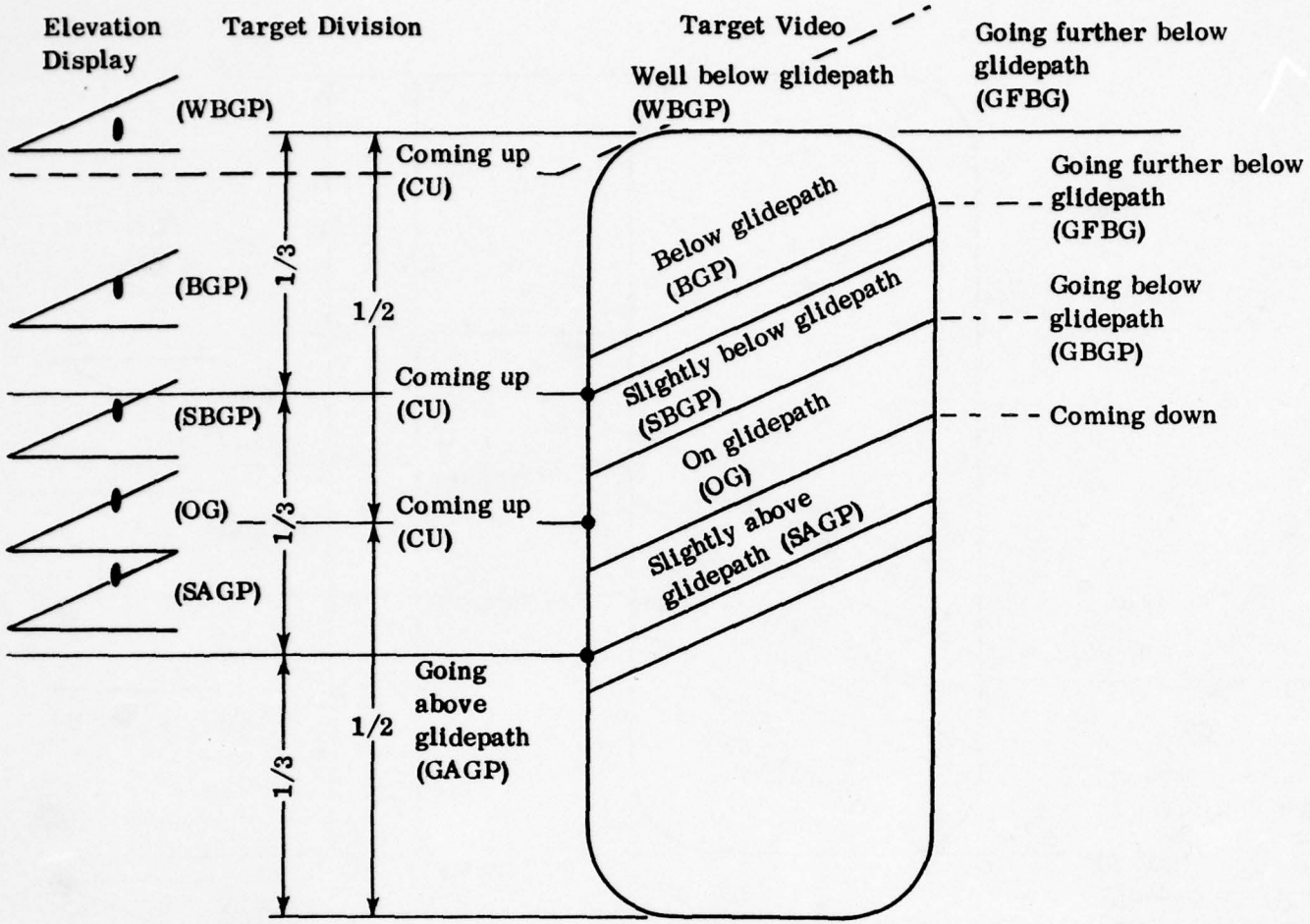

Figure 10. Elevation Display

TABLE 26. LEVEL 4 OF THE GCA-CTS SYLLABUS (Cont).

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T4.8	Table 10	Issue glidepath advisories.	AG, WAGP, GFAG	Introduce glidepath • Position advisories: Above glidepath (AG) and well above glidepath (WAGP); • Trend advisory: going further above glidepath (GFAG). Phases I, II, III. • See figure 11.	Issue position (OG, SAGP, AG, WAGP, SBGP, BGP, and WBGP) and trend (GAGP, GFAG, CD, CU, GBGP, and GFBG) advisories.	To train glidepath advisories.	Transmit proper position and trend positions 4 of 5 times. Of course and position messages, transmit not more than 50% nor less than 20% course messages.		7110.65-1203	

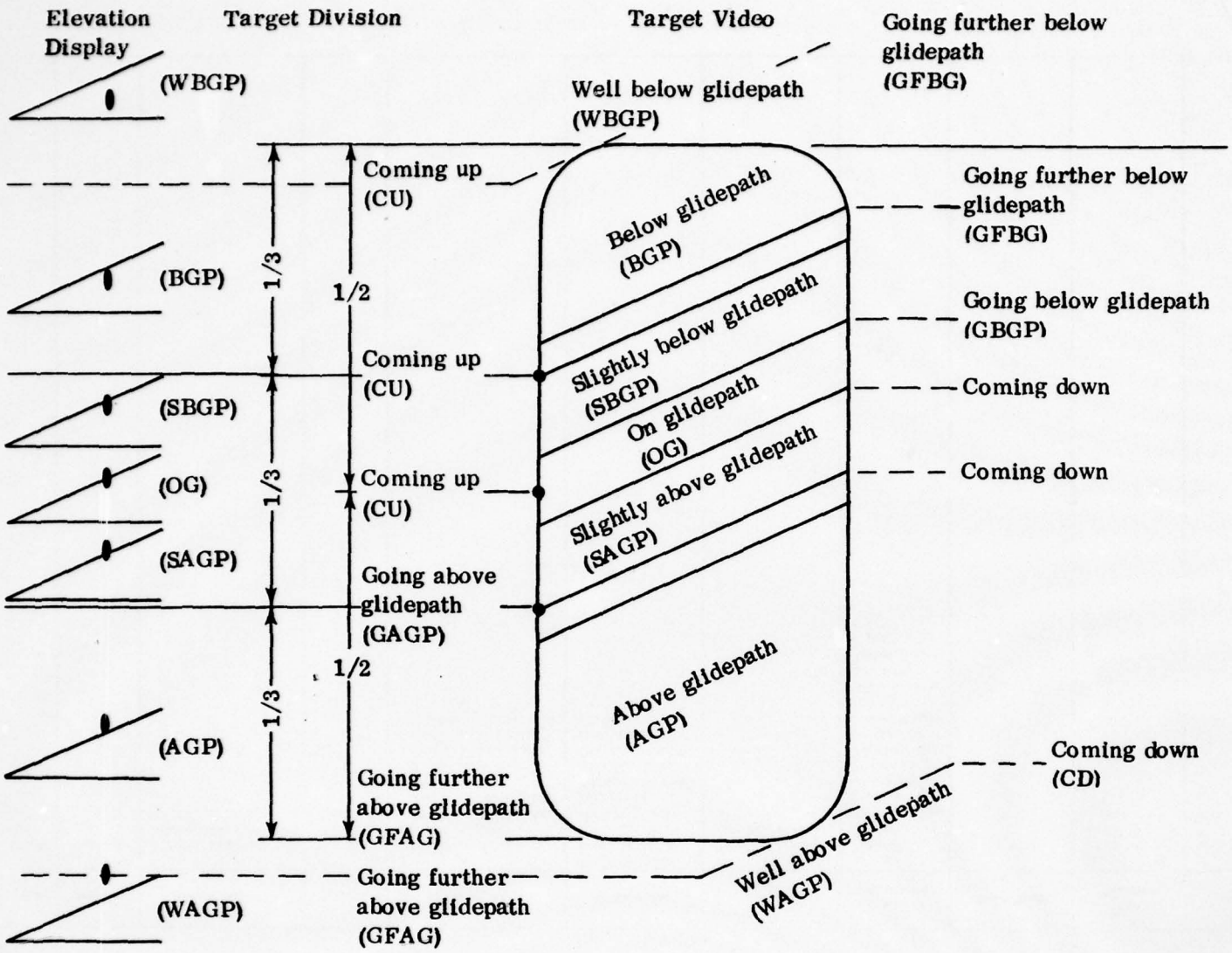

Figure 11. Elevation Display

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LEVEL 6 – In this level, the student learns the procedures for coordinating with the feeder controller as shown in Table 28. When this level is completed, the student will have acquired all the verbal skills required to conduct a normal approach. Most of this level will be devoted to practice and refinement of skills and to the integration of those skills acquired in Level 5 with previous skills.

LEVEL 7 – Through the previous levels, performance requirements have gradually been made more stringent to allow the trainee's skills to gradually approach the terminal objective standards. In level 7, the trainee will be given practice exercises until he demonstrates performance that meets the standards given in the behavioral objectives section of this document for the applicable terminal objectives. When this level of proficiency is attained, or after the maximum allowable number of exercises, the performance run or final examination will be administered. The trainee will have the opportunity to replay these runs before they are observed by the instructor if he chooses, so he will know his preliminary grade. The instructor will have the option of modifying the data base if necessary to resolve any misrecognitions, and then requesting that the run be scored based on the updated information.

LEVEL 8 – This is an enrichment level designed to make the student proficient in servoing to maintain or regain radar contact. All students who successfully complete the course are expected to reach this level. The form of instruction is shown in Table 29.

LEVEL 9 – Another enrichment level topic, emergencies (no-gyro, loss of radar contact, encroachment, erratic movement, and low altitude alerts) are introduced at this level as shown in Tables 30 through 33. Notice that there are no criteria for advancement out of this level. Once the student has mastered the topics presented, the training system will continue to provide problems of all kinds. Thus the student will be able to practice and become more proficient.

TABLE 27. LEVEL 5 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior *	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T5.1	Table 14	Issue a break in the controller's transmission series to give the pilot a chance to transmit any needed communication.	Transmission break.	Introduce the transmission break and show proper timing. Phase I, II, III.	Transmit "Transmission break". Adjust microphone if: • VU level reading has been low • Pilot responds transmissions weak but clear.	To allow pilot to make any needed transmissions.	While conducting a PAR approach issue "Transmission break" at least once between 1 and 5 miles 4 of 5 times.	While conducting a PAR approach issue "Transmission break" at least once between 1 and 5 miles. Terminate transmission break when pilot responds, or after 3 seconds. Transmit the message after "Begin descent" message has been given. Issue one or two during an approach.	7110.65-1203a NOTE - Controller should not key the radio transmitter continuously during radar approaches to preclude a lengthly communication block. The decision on how often transmitters are unkeyed is the controller's prerogative.	
T5.2		Transmit advisories at a continuous and regular rate.		Introduce the 5 second rule allowing 5 runs at 10 seconds. Phase II, III.	Learn to transmit advisories at a continuous and regular rate of not faster than one phrase per 1 second or slower than one phrase per 5 seconds.	To establish a regular and even flow of advisories from the controller	While conducting a PAR approach issue advisories no faster than 1 second between transmission and no slower than one phrase per 5 seconds.		1152 - Lost Communications.	

TABLE 27. LEVEL 5 OF THE GCA-CTS SYLLABUS (Cont)

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T5.3	Table 16	Transmit the Over landing threshold advisory, informing the pilot that his craft is over the approach end of the runway. *Transmit course* information (on course not required)	Over landing threshold	Introduce transmission "Over landing threshold" show and display for five runs the landing threshold.	Transmit "over landing threshold" plus or minus one second of the A/C contacting the landing threshold. Transmit position in relation to centerline.	Inform the pilot when the aircraft is passing over the landing threshold.	While conducting a PAR approach, transmit over-landing threshold 5 of 5 times.	Located approximately 1/4 inch outboard of the touchdown point.	7110.65-1211 a. Continue to provide advisory course and glidepath information until the aircraft passes over the landing threshold. 7110.65-1211: Inform the aircraft when it is passing over the landing threshold and inform it of any deviation from centerline. Phraseology: Over landing Threshold (position with respect to centerline)	
		Inform the pilot that the controlled approach is being terminated.	Over	Tie overlanding threshold, position with respect to centerline and OVER together. Phases I, II, III.	Transmit "OVER" following overlanding threshold and position in relation to centerline.	To inform the pilot the controlled approach is being terminated.	While conducting a PAR approach transmit overlanding threshold with position with respect to centerline ending "over" 5 of 5 times.			

TABLE 27. LEVEL 5 OF THE GCA-CTS SYLLABUS (Cont)

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T5.4	Table 17	Transmit the rollout instructions to the pilot. Release the button to the pattern controller.	Contact tower after landing, over-; Button x clear (to pattern controller)	Introduce rollout instructions. • where to obtain • where to give • how to give • to whom Phases I, II, III	Transmit rollout instructions to pilot on a full stop approach after twenty seconds following "over"	To inform the pilot of procedures to follow after landing.	After completing a full stop approach, issue rollout instructions no sooner than 20 seconds or later than 40 seconds after "over" 5 of 5 times.		7110.65-1212. Issue communications transfer instructions.	

TABLE 28. LEVEL 6 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T6.1	Table 18	Handoff control of the aircraft to the pattern controller.	On the go C/S, button X; C/S missed approach button X.	Introduce procedure to handoff control for a waveoff and low approach termination. Phases I, II, III.	Given a waveoff or low approach termination situation: • Give the pattern controller call sign and button number at time of waveoff within 60 seconds of landing threshold. • Verify pattern controller has responsibility for the A/Cs control. Monitor frequency until the pattern controller transmits to the A/C.	To produce a smooth change from final to pattern controller.	While conducting a PAR approach handle three waveoffs and two low approach terminations without error.		7110.65 Section 5 Radar Handoff	
T6.2	Table 3	Accept hand-off from pattern controller.	C/S radar button X; give me button X; C/S this is your final controller, how do you hear me?	Introduce a procedure for accepting a handoff. Phases I, II, III.	The final controller monitors the communications channel and the dialog between the pattern controller and the pilot; • Acknowledge the handoff message; • Confirms that 50% of AZ target has appeared as a target on his display; • Establishes radio contact with the A/C.	To produce a smooth change from pattern controller to final controller.	While conducting PAR approaches, accept control 10 out of 10 times.		7110.65. Section 5 Radar Handoff	

TABLE 28. LEVEL 6 OF THE GCA-CTS SYLLABUS (Cont)

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T6. 3		Wheels down check	Wheels should be down.	Introduce transmission and placement, before the A/C starts descent on final approach, remind the pilot that wheels should be down unless he has previously reported wheels down.	• Wheels down check	To ensure wheels are down prior to landing	While conducting a PAR approach transmit wheels down check 9 of 10 times unless wheels down has been given		7110.65, 1223	

TABLE 29. LEVEL 8 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T8. 1		Adjust the radar scan pattern to keep the A/C within the scan during an approach.		Move the target out of the beam or require the student to servo to cause his/her A/C to be lost.	Servo to maintain or regain contact of the radar target during a PAR approach.	To train the student to servo in the proper direction to gain or maintain radar contact.	Maintain the target within the radar beam 90% of the time, 4 of 5 times.			Enrichment training

TABLE 30. LEVEL 9 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T9. 1		Detect No-gyro symptoms.	"Make Half-Standard rate turns." "This will be a No-Gyro PAR approach"	Present emergency conditions (no-gyro symptoms) while conducting a precision approach and allow the student to recognize the emergency. Act as the pilot and report that the compass is not functional. Phases I, II, III	Detect no-gyro symptoms. Warn the pilot that his A/C is not performing the assigned course. Inform the pilot the approach will be conducted as a no-gyro precision approach. Transmit the one half standard rate turn advisory.	To train student to detect a no-gyro situation.		Give warning if more than 1/4 mile elapses after a turn is issued, and less than a 2° change is observed. Student has 1/2 mile to correct the A/C's course after a warning of heading deviations.	7110. 65 1153	Enrichment training

TABLE 31. LEVEL 9 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T9.2		Control the A/C's heading during a no-gyro approach while on final.	Turn Left/ Right Stop turn	Respond to "Stop turn" and "Turn Left/right" Phases I, II, III.	Control the A/C's heading during a no-gyro approach while on final. Compute and issue Turn Left/Right, and Stop Turn commands for a no gyro approach. Estimate start and stop turn times.	To train student to run a no-gyro approach.		5 or 10 degree turns outside 3 miles – 2, 3, or 4 degree turns within 3 miles.	7110.65 1153	Enrichment training

TABLE 32. LEVEL 9 OF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T9. 3		Conduct a waveoff due to emergency situations. • Radar contact lost, clearance given • Radar contact lost, no clearance • Targets encroach within three miles of one another • Target moves in a very erratic manner.		Present emergency conditions • Loss of radar contact • Another target on PAR approach, less than 3 miles separation • Move target in a very erratic manner Phases I, II, III.	Conduct an emergency wave-off • "Radar contact lost, if runway not in sight climb and maintain 3000 feet, turn right, proceed directly to point bravo, hold until advised by GCA. over." • "Radar contact lost, climb and maintain 3000 feet, turn right, proceed directly to point bravo, hold until advised by GCA, over." • "Execute missed approach" • "Climb and maintain 3000 feet, turn right heading 270."	Teach the student to react to emergency wave-off conditions.			7110.65 1174	Enrichment training

TABLE 33. LEVEL 9 IF THE GCA-CTS SYLLABUS

Task	Reference	Learning Objectives	Voice Reference Patterns	Training Systems	Student Behavior	Purpose	Criterion for Advancement	Rule of Thumb	FAA Regulations	Notes
T9.4		Transmit a low altitude alert.		Present a low altitude situation – Phases I, II, III.	Detect a low altitude alert. Transmit: "Low altitude alert, check your altitude immediately."	To train the student to detect low altitude approaches and to respond properly.		Whenever the ratio is greater than one (ratio of target width below glidepath to miles from touchdown)		Enrichment training

SECTION IV

FUNCTIONAL SPECIFICATION

General

In the previous section, the GCA-CTS was described from the perspective of the system user. This section details the major functions which will be required to support the system as described. The functional requirements will provide the basis for the system design effort.

Special Simulation Requirements

In the following paragraphs, the special devices which would augment the GCA-CTS are described. Only the tower clearance signal was simulated in the laboratory GCA-CTS (and that only simplistically), hence the training benefit of these devices is difficult to determine. Some, such as the servo mechanism, appear to be very important; others, such as the VU meter, may be less important. The effort necessary to provide these special devices will be addressed early in the design phase. By balancing the cost of the devices against their training benefits, implementation decisions can be made.

SERVO SWITCH – An input device is required to simulate the antenna servo controls. The switch must accept 4 entries: Up, down, left, and right. It should return automatically to center.

FOOT ACTUATED MICROPHONE KEY – A foot actuated microphone key would add a measure of face validity to the training system. The device used at NATTC consists of a sturdy metal plate, roughly 8 x 10", on which a bar is mounted. Depressing the bar allows the student to communicate

with the pilot over the selected radio frequency. Several degrees of simulation realism are possible. The most realistic approach would be to turn the VIP on and off in response to the microphone key and the ICS buttons, with an indicator available to the GCA-CTS as to the destination of the transmission. If, however, runs are not recorded through the VIP for replay, there is the possibility that GCA-CTS would not hear the student because the proper keys were not depressed, even though the R/T could be heard during replay. The better solution would be to implement foot key, ICS and radio frequency button state inputs to GCA-CTS, while leaving the voice recognition system listening at all times. The state inputs could be used to augment recognition and to explain the nature of errors in selection.

VU METER – The VU meter provided with the speech recognition hardware enables the talker to achieve the speech level which is best for recognition. If this meter were monitored by the GCA-CTS, it would be useful in diagnosing speech recognition problems. Since the GCA-CTS will not necessarily have a person who is familiar with speech recognition procedures to help it out, this source of information could be valuable to the training system.

RADIO FREQUENCY/INTER-CONTROLLER COMMUNICATION SYSTEM (ICS)/CLEARANCE REQUEST PANEL – A set of inputs is required to enable communication among the approach control team members. Ideally, selections should be input via a control panel which provides visual, tactile and auditory feedback in response. In general, the panel should be a separate unit placed well within the limits of the student's peripheral vision. To minimize confusion, functions of the various lights and buttons should be distinct and well specified in their arrangement on the panel. Each button should be approximately one half inch square. The lights should be bright enough to be easily seen in the darkened control room environment but not so bright as to be annoying or distracting to the student.

The ICS is used by the PAR controller to communicate with the pattern controller or to monitor approaches conducted by other positions. The minimal ICS panel should include at least one button-light. The button-light must be depressed in order for the PAR controller to communicate with the pattern controller. Once depressed the button must remain depressed until depressed again. In addition, the button-light will be illuminated as a red source when the button is depressed and will remain on until the button is deselected.

The GCA clearance light system consists of one button-light and two individual lights. The system is used by the PAR controller to request landing clearance from the tower and by the tower to inform the controller of landing clearance or to cancel that clearance. The button-light is illuminated as a white source when the button is depressed. When the button is depressed it remains depressed and the white light remains on until the controller depresses it again. The cleared light is a green light that indicates that the tower has granted the aircraft clearance to land. The second light is a red flashing light that indicates that the tower has cancelled the landing clearance. In addition to the flashing red light an auditory alarm is also activated when the tower cancels clearance.

The radio frequency panel consists of a minimum of two sets of two button-lights. In each set the first button-light is the frequency select button. When the particular radio frequency is available for use the button-light is not lit. When the frequency is in use the button-light is amber and the controller will hear an alarm in his/her headset if he/she selects the frequency. When the frequency is available and the controller selects it, the button-light turns and stays green and the button remains down until deselected. The second button-light of the set is the monitor button-light which the PAR controller selects when he/she wishes to monitor the communications between the pattern controller and the aircraft pilot. When the button is depressed it remains depressed until depressed again. In addition the amber light within the button comes on and stays on.

Although the details of communications systems vary throughout the fleet, the systems are the same in principle. Therefore, the layout of the buttons and lights is not as significant as similarity, in principle, of operation. This admits the possibility of using the special function keys on the trainee station keyboard to simulate the buttons, with the names of the associated colors written on the screen. However, the feedback provided by a more realistic simulation would be valuable. The cost to implement an external device will be balanced against the training benefits during the system design phase.

Operational Requirements

The GCA-CTS has a set of well defined functions to perform. These can be organized hierarchically to give an indication of their relationships and an overall view of GCA-CTS.

FUNCTIONAL ORGANIZATION – Figure 12 is intended to show that overall responsibility for the sequencing of events resides with the training system executive, and that major serial functions (shown in the large blocks) are performed utilizing common subfunctions. In the paragraphs that follow, the requirements placed upon these and other functional elements are described. These general requirements will provide the basis for the system design effort.

Training System Executive – This system element has the overall responsibility for the course of events in the student's training experience. It sequences the problems, selects remedial training, provides rest periods at 50 minute intervals, and ultimately determines when the student is ready for the final examination.

GCA-CTS Initiation – A system element will be required to start the GCA-CTS. This element will ensure that the activities of the training system

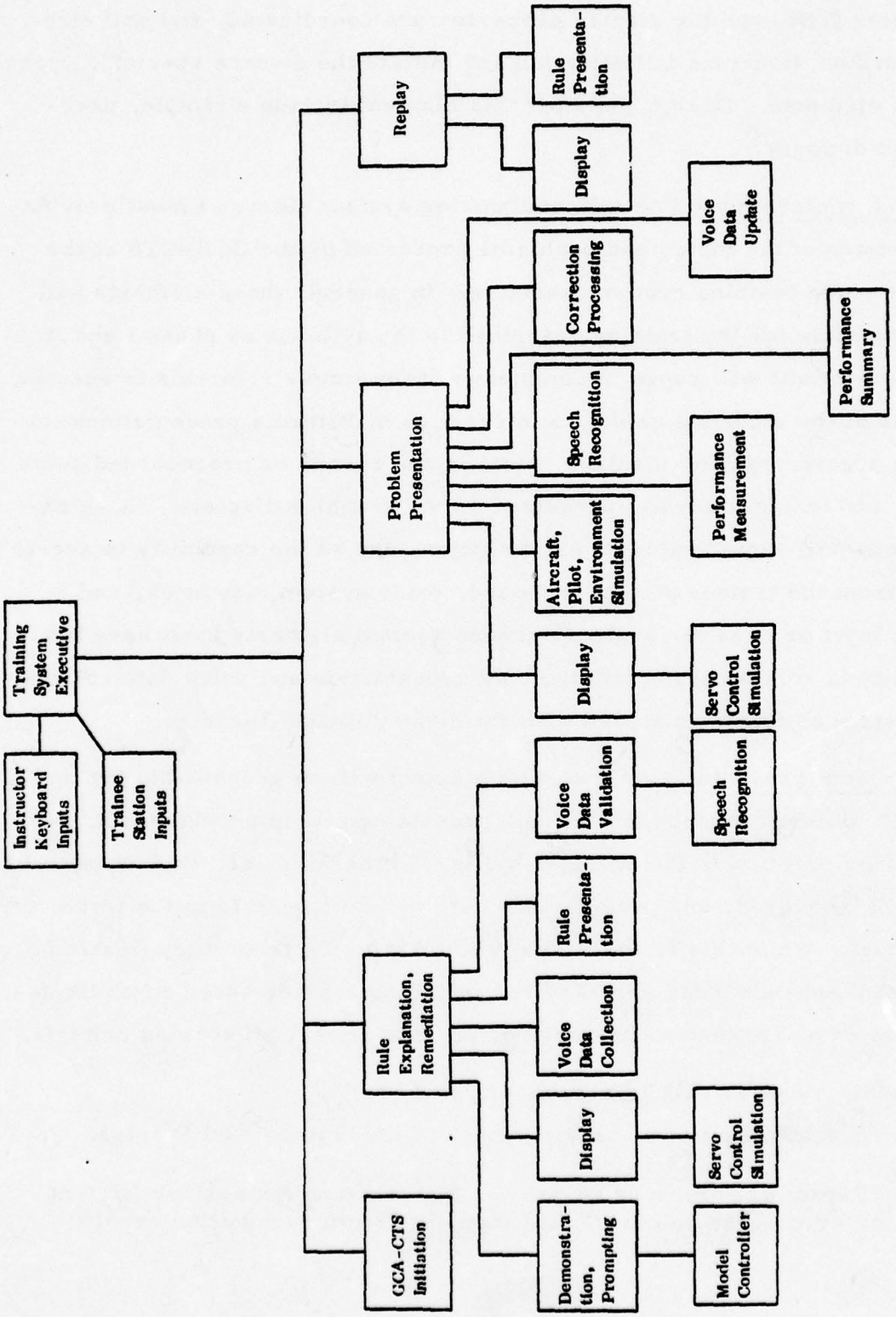

Figure 12. Functional Organization

controller (TSC) and the display processor are coordinated, and will also perform data structure initialization and initiate the diverse special purpose system elements. Design goals for this element include a simple, user-oriented dialogue.

Rule explanation – The rule explanation system elements must provide explanations of the topics and problems presented by the GCA-CTS at the request of the training system executive. In general, these elements will be responsible for the training described in the syllabus as phase I and II. The explanations will range in complexity from simple referrals to specific sections of the student's guide, to interactive multimedia presentations involving special dynamic displays, synthesized speech or prerecorded audio output, and textual material presented on the graphics display. These explanations will require student participation, and so the capability to accept inputs from the trainee station keyboard, voice system, joy stick, and special input devices is required. These system elements must have the capability to communicate with the rule presentation and voice data collection system elements, and also with the display image librarian.

Problem presentation – A system element will be responsible for the phase III syllabus modes, that is, for presenting problems which will give the trainee practice in the acquired skills. In these modes, student performance will be scored, and performance data will be available to the instructor on request. While this is conceptually similar to the laboratory GCA-CTS, significant enhancements are required including scoring based on skills acquired to date, correction processing, and use of revised scoring criteria.

Replay – Replay will be capable of providing:

a. Synchronized audio tape playback of the trainee's advisories.

b. Repeat of erroneous advisories by the voice synthesizer (so that controller errors can be clearly distinguished from recognition errors).

c. Explanation of the rule governing the error situation (only at the first instance of the run), replete with special displays in early stages of training.

d. The display of a dim aircraft track history over the entire run.

The replay options will include:

a. Fully annotated replay (all of the above).

b. Annotated replay (errors mentioned, rule repeat suppressed, but otherwise the same).

c. Brief replay (a quick reconstruction of the aircraft track history only).

After the final examination, a special replay mode will enable the instructor to modify the performance information to resolve misrecognitions and to initiate final examination scoring based on the updated information rather than on accumulated run statistics.

Replay will be invoked by a keyboard entry at the instructor or trainee station. Replay of a particular run can be repeated as many times as desired after a run. As soon as a new scoring run begins, any existing replay file and audio recording will be destroyed.

Performance (P) run (final examination) — The P run will consist of a run or set of runs similar to those already completed in the problem presentation mode. Both the examination and the measurement criteria will be developed in accordance with the principles specified in UDI-H-2104. The P run will differ from problem presentation runs in that no speech data updating will be done, the instructor will have the option of resolving misrecognitions before the final score is computed, and special output is required. The P run is as much a test of the GCA-CTS as it is of the student, and therefore the output must be complete enough to allow the instructor to pinpoint those areas in which training was deficient. Thus (in accordance with NTEC specification N-215-266, paragraph 3.6.3) "deficiencies on the part

of the trainee shall be automatically noted by the training system with a cross reference both to specific tasks and skills and to that portion of the syllabus wherein the skill was taught."

SPEECH RECOGNITION – The speech understanding subsystem (SUS) must have the capability to recognize the phrases shown in Table 34 which have been extracted from Appendices A and C. In general, a SUS output will be a message unit corresponding to a complete PAR transmission, therefore stylized phrases must be concatenated. In addition, every message not understood must be reported to the training system.

The GCA vocabulary in itself places a very demanding requirement on the SUS. It includes many similar phrases, and it contains both very long and very short utterances. The demands upon this subsystem are increased by the fact that students will not be well trained talkers, and further, will be expected to issue advisories in rapid succession during some portions of an approach. Considerations in the design of the SUS will include:

a. The use of auxiliary sources of information such as the phase of the approach, destination of the transmission (radio frequency or ICS), and type of approach, to reduce processing time and increase accuracy.

b. The development of ways to adequately characterize and recognize phrases of diverse lengths.

c. Providing techniques to handle common errors such as "turn right heading *one... six... five.*"

d. Devising ways to distinguish probable misrecognitions from actual controller R/T errors, and correcting suspected misrecognitions before issuing the advisory to the training system.

e. The possibility of self-monitoring for purposes of requesting speech data validation when confidence in recognition declines.

In general, it appears that the demands of the training system dictate that the SUS be highly application dependent, utilizing every available source of information to ensure recognition.

TABLE 34. PHRASES TO BE RECOGNIZED.

Reference (Appendix A)	Phrase #	Phrase	Notes
6, 7, 25, 30, 31, 40, 47, 48, 50, 51, 54	0	...zero(...)	
	1	...one(...)	
	2	...two(...)	
	3	...three(...)	
	4	...four(...)	
	5	...five(...)	
	6	...six(...)	
	7	...seven(...)	
	8	...eight(...)	
	9	...niner(...)	
1	10	Position 1, roger.	There will be only 1 position.
2, 4, 6, 7, 9, 26, 29, 41, 54	11	C/S_1... (e.g. Navy 728)	Select 3-5 call signs to be used for all approaches.
	12	C/S_2...	
	13	C/S_3...	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.).

Reference (Appendix A)	Phrase #	Phrase	Notes
3	14	...radar, button 1.	Again, only 1 position.
4	15	This is your final controller, how do you hear me?	
5	16	How do you hear me now?	
6, 7, 44, 54	17	...over.	
8	18	Wheels should be down, over.	
9	19	On the go...	
9	20	...button 1.	
3	21	Give me button 1.	
26, 27	22	(...) approaching glidepath(...)	
41	23	...do not acknowledge further transmissions.	
28	24	Begin descent.	
10	25	On glidepath.	
13	26	Slightly above glidepath.	
14	27	Slightly below glidepath.	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.).

Reference (Appendix A)	Phrase #	Phrase	Notes
11	28	Above glidepath.	
12	29	Below glidepath.	
15	30	Well above glidepath.	
16	31	Well below glidepath.	
17	32	Coming up.	
18	33	Coming down.	
21	34	Going above glidepath.	
22	35	Going below glidepath.	
18	36	Going further above glidepath.	
19	37	Going further below glidepath.	
6,31,47,51	38	(...) Turn right heading...	
7,30,48,50	39	(...) Turn left heading...	
54	40	(...) heading...	
36	41	On course.	
35	42	Slightly right of course.	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.).

Reference (Appendix A)	Phrase #	Phrase	Notes
34	43	Slightly left of course.	
50, 52	44	Right of course...	
51, 53	45	Left of course...	
30, 32	46	Well right of course...	
31, 33	47	Well left of course...	
32, 33, 52, 53	48	...correcting.	
37	49	6 miles from touchdown.	
37	50	5 miles from touchdown.	
37	51	4 miles from touchdown.	
37	52	3 miles from touchdown.	
37	53	2 miles from touchdown.	
37	54	1 mile from touchdown.	
38, 39	55	At decision height(...)	
39	56	...too high for safe approach...	
39	57	...too low for safe approach...	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.).

Reference (Appendix A)	Phrase #	Phrase	Notes
39	58	...too far right for safe approach...	
39	59	...too far left for safe approach...	
39	60	...if runway not in sight execute missed approach.	
39	61	...if runway not in sight, climb and maintain 1500. . .	
24	62	Climb and maintain 1500. . .	
40	63	Wind...	
40	64	...at...	
40	65	Cleared for low approach(...)	
40	66	Cleared for touch and go(...)	
40	67	Cleared to land(...)	
42	68	Transmission break.	
43	69	Over landing threshold.	
45	70	Contact tower after landing, over.	
46	71	Button 1, clear.	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.).

Reference (Appendix A)	Phrase #	Phrase	Notes
49	72	Correction.	
C1	73	...this will be a no-gyro approach, over.	The following are enrichment topics.
C2	74	This will be a no-gyro approach.	
C3	75	Make half standard rate turns.	
C4	76	...turn right, over.	
C5	77	...turn left, over.	
C6	78	...stop turn, over.	
C7	79	Turn right.	
C8	80	Turn left.	
C9	81	Stop turn.	
C10, C11	82	Radar contact lost...	
C10	83	...if runway not in sight...	
C10, C11, C12	84	...climb and maintain 3000. . .	
C10	85	...turn right, proceed direct point Bravo, hold until advised by GCA, over.	

TABLE 34. PHRASES TO BE RECOGNIZED (Cont.)

Reference (Appendix A)	Phrase #	Phrase	Notes
C13	86	Low altitude alert, check your altitude immediately.	
29	87	. . . Three and one half miles. . .	The map position should be called to the nearest half mile.
29	88	. . . Three miles. . .	
29	89	. . . Two and one half miles. . .	
29	90	. . . Two miles. . .	
29	91	. . . One and one half miles. . .	
29	92	. . . One mile. . .	
40	93	. . . twelve	A few representative wind speeds may be used to allow a more realistic wind advisory
40	94	. . . fifteen	
40	95	. . . twenty	
40	96	. . . twenty-five	
40	97	. . . thirty	
37	98	7 miles from touchdown.	
37	99	8 miles from touchdown.	

VOICE DATA COLLECTION – The GCA-CTS must have the capability to collect input feature patterns and to create voice reference patterns (VRPs) for the concatenated phrases shown in Appendices A and C. This function must be available at the request of the rule explanation module, and also by request at the instructor's console. It must be able to accept up to ten repeats of each vocabulary item, in any order, for VRP formation. It should replace the oldest data first if more than ten repeats are provided. It must have the capability to form VRPs which can be used to recognize both long and short utterances.

VOICE DATA VALIDATION – The entire process of voice data collection and validation ought to be made as transparent as possible to the student, and yet he will need some specific feedback in this area to enable him to learn to use the voice system effectively. This system element provides this feedback and confirms that the VRPs are adequate for speech recognition. It identifies vocabulary items for which recognition accuracy is poor so that retraining can be undertaken. Two modes should be available on request: prompted and not prompted. In either case, the validation can be attempted over all items in the vocabulary, or over a subset.

VOICE DATA UPDATE – A system element will be designed to test the concept of dynamically updating voice reference patterns in a way almost completely transparent to the user. Since the student is just learning the R/T when the VRPs are formed, it is conceivable that his verbalization patterns will change as he becomes familiar with the R/T and develops his personal style. In order to keep abreast of these changes, the concept of updating existing VRPs during the course of training will be tested. The efficacy of this feature will determine whether or not it is implemented in the delivered system.

RADIO FREQUENCY/ICS/CLEARANCE REQUEST PANEL MONITOR – A system element will monitor input from the simulated panel and will

control the associated light and audio feedback. If the special function keys on the 6053 keyboard are used to accept the inputs proper to this panel, the light displays will have to be simulated on the graphics display or CRT, with the colors displayed by name. Various training system elements will require notification when button selections are made. This system element will also have to respond to clearance requests in accordance with conditions established for the particular exercise.

DISPLAY – A display image librarian will maintain the special display lists available on call to the various display processing elements. These elements will modify the display lists in real time in accordance with simulated environmental conditions. Special displays will be required for some of the phases I and II of instruction as described in the syllabus. These will be detailed during the upcoming system design phase.

Simulation of the PAR radar display is also required. This simulation must be accurate to insure *transfer of training*. Figures 13 and 14 respectively show the azimuth and elevation radar geometries. Figure 15 shows the radar coverage from the aircraft's perspective. Figure 16 shows the salient features of the PAR display, including the logarithmic range scale, target expansion and target trail. Not illustrated is the radar sweep which should be included for face validity according to the instructors at NATTC. Since this may be a distracting element in the preliminary phases of training, the sweep should be available at training system request. The sweep rate of each antenna is approximately 2 sweeps per second. The sweep duration is 250 msec. The antennae are synchronized so that, as the elevation radar sweep appears to hit the bottom of the display, the azimuth starts, that is the antenna moves to the left. Regular variations are introduced into this pattern to prevent the controller from fixating or becoming hypnotized. A relatively simple simulation of sweep is considered to be sufficient, with the display brightening uniformly (except for the target trail) for the sweep duration and the target return advancing incrementally. The display

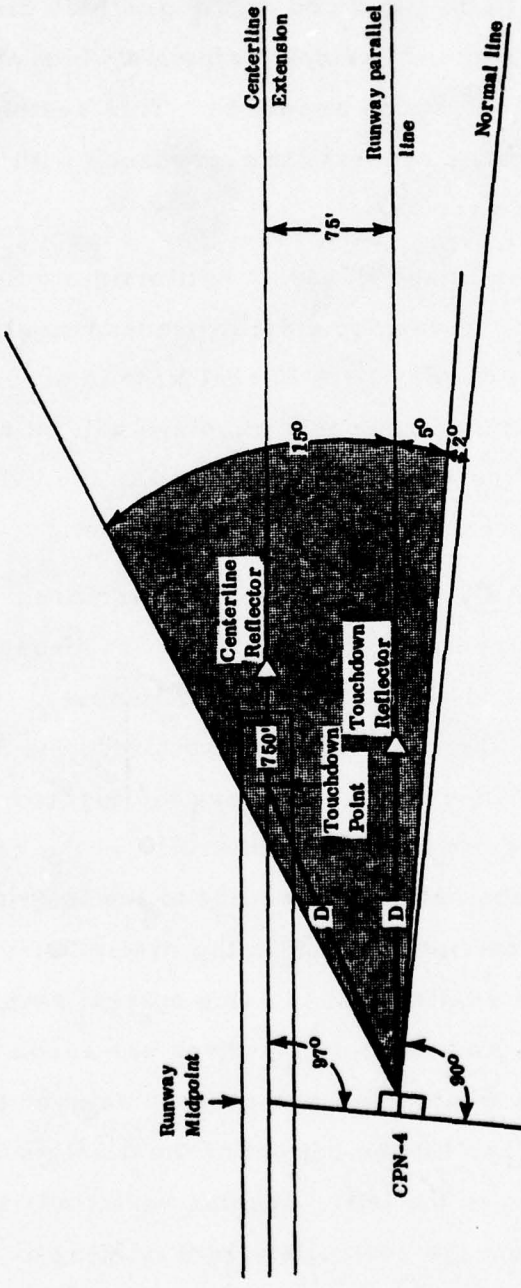

Figure 13. Typical Azimuth Radar Geometry. (Exaggerated to show details. The shaded areas show the 20° sweep coverage.)

Figure 14. Typical Elevation Radar Geometry. (The 7° sweep coverage is represented by the shaded area.)

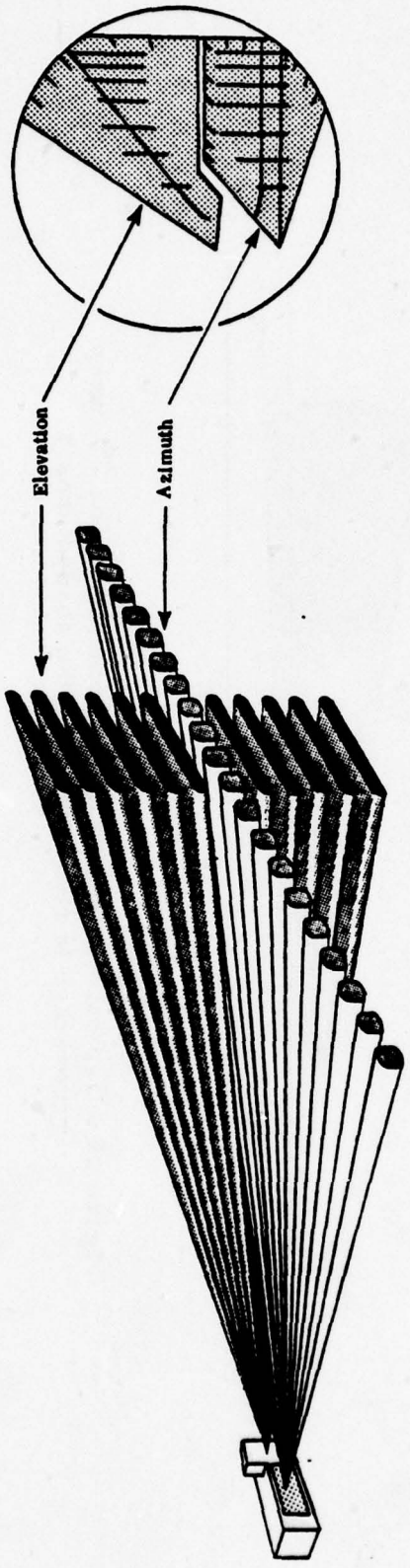

Figure 15. Par Radar Scan. (From aircraft's perspective.)

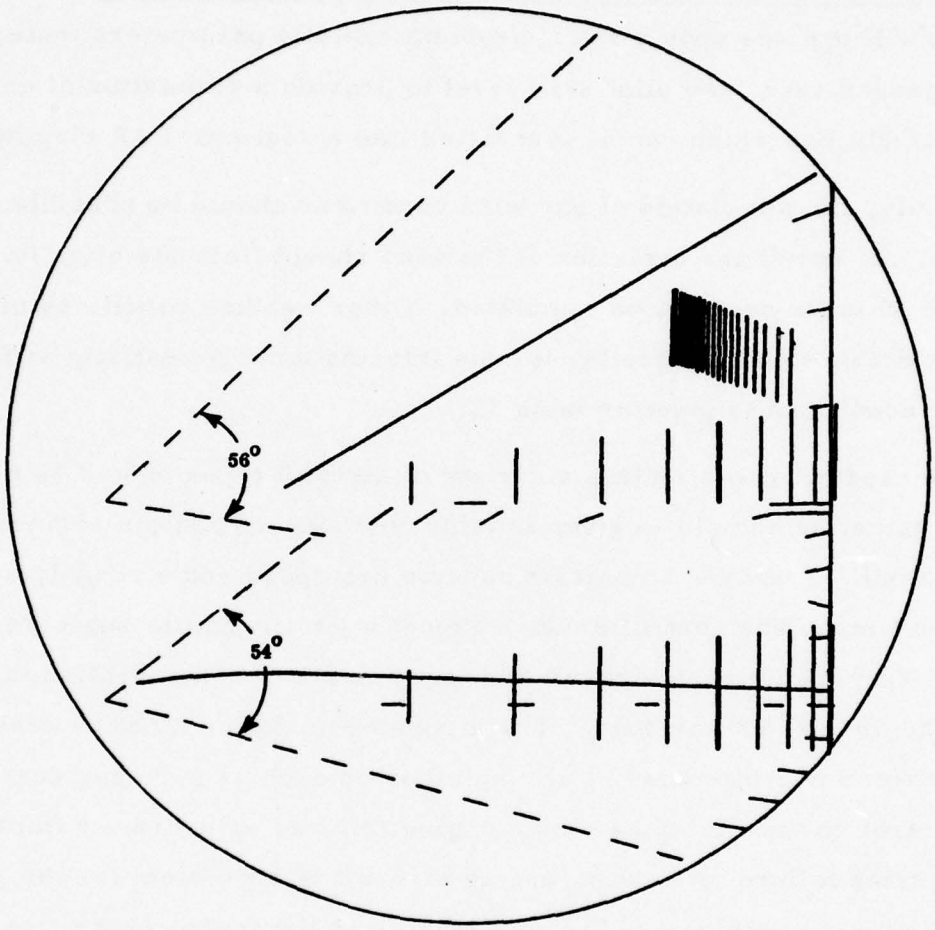

Figure 16. Par Radar Display. (The elevation above shows the 7° sweep expanded 8 times. On the azimuth, below, the 20° sweep is expanded to 27 times.)

can then gradually fade. The sweep rate and phosphor are such that the display never completely disappears while the radar is operational.

AIRCRAFT, PILOT AND ENVIRONMENTAL SIMULATION – This system element will operate upon a set of problem specific parameters including wind, aircraft type, and pilot skill level to provide a simulation of environmental conditions which can be translated into a realistic PAR display.

Ideally, the simulation of any wind conditions should be possible. For realism, the speed and direction of the wind should fluctuate slightly. Winds of above 30 knots need not be simulated. Other weather conditions must be made available to the controller for his information. A realistic sample of weather conditions is given in Table 35.

The capability to simulate a variety of aircraft types should be provided. A representative sample is given in Table 36. The simulation requirements are minimal. The most important aspects are speed and a roughly accurate response time. The controller does expect a jet aircraft to begin its descent more quickly than a prop aircraft and takes this into consideration in issuing the begin descent advisory. The aircraft simulation must be designed to allow some contingencies to be implemented such as gyro compass failure, control surface icing, a single engine failure, or hydraulic failure. A single engine failure on a multi-engine aircraft is a problem for the pilot, but is apparent to the controller only insofar as the feeder controller reports the condition and sets up a short approach. Hydraulic failure is more apparent to the controller and is manifested in "jerky" aircraft maneuvers.

Pilot skill varies significantly and the trainee should be exposed to less skillful pilots, especially in the more advanced exercises.

TABLE 35. TYPICAL WEATHER CONDITIONS

The first letter, if present, indicates measured (M) or estimated (E) conditions. The last digit is visibility in statute miles. If it is less than 7 miles, it must be qualified by an obstruction to vision indication: F(fog), H (haze), R (rain), R- (light rain). Other abbreviations indicate coverage: OVC (overcast), BKN (broken), SCT (scattered), CLR (clear).

CLR 10

M 8 OVC 2 1/2 R

9 SCT 20 BKN 7

E 14 BKN 20 OVC 4 F

M 12 BKN 18 OVC 3 R

20 SCT 25 BKN 30 OVC 10

M 50 OVC 15

15 SCT 20 BKN 10

M8 BKN 10 OVC 1 1/2 RF

M 10 OVC 2 F

M 15 BKN 5 H

M 8 BKN 20 OVC 7

M 100 BKN 10

E 180 OVC 20

M 60 BKN 80 BKN 5 R-

TABLE 36. TYPICAL AIRCRAFT TYPES

Call Sign	Type	Approach Speed	Prop or Jet	Landing Weight
Army eight seven six	U-21	98	TURBO PROP	8,700
Air Express four fifty one	727	130	JET	135,000
Wheelchair two zero	C-2	110	TURBO PROP	42,000
Marine six eight seven	A6	115	JET	28,000
Sioux Falls four one two	T34	85	PROP	1,800
Navy three one zero	P3	130	TURBO PROP	114,000
Navy four two one	A7	125	JET	23,000
Air Force zero one zero	F4	130	JET	41,000
American twenty one	747	130	JET	600,000
Rock River niner	A4	125	JET	16,000
Air Force three zero seven	T38	156	JET	11,050
Eastern one ten	L1011	138	JET	330,000
November five eight seven	PA18	65	PROP	1,650
Army six niner eight	OV10	76	TURBO PROP	12,400
Navy zero zero four	F14	120	JET	40,000

SERVO CONTROL SIMULATION – A system element will position the azimuth and elevation radar beams in response to joystick inputs. When the student servos, this system element will cause the simulated radar beam to move in space. The position of this radar beam is used by the radar display simulation to position the mile marks and paint targets, thus as the student servos, the mile marks will move and any radar returns in the scanned area will be displayed. Servoing up and down causes the azimuth antenna to move up and down, and the mile marks on the elevation indicator track this movement. Servoing right causes the elevation antenna to move to the left (looking toward the aircraft) and the mile marks on the azimuth to move up. Servoing left causes the elevation antenna to move to the right and the mile marks to move down on the azimuth display.

DEMONSTRATION/PROMPTING – A system element will utilize the selections made by the model controller and apply the proper timing and message rules to provide demonstration precision approaches or segments thereof. This will enable the student to observe professionally conducted approaches both for purposes of orientation and remediation. A valuable adjunct to this system element will be its prompting function: it will have the capability to prompt the student during the first few approaches wherein new skills are to be applied. At training system request it must have the capability to select, for demonstration or prompting, only those items which relate to the topic at hand. In addition, the prompting function can notify the speech validation function to expect and validate the prompted phrase.

MODEL CONTROLLER – A simulation of an ideal PAR controller is required to provide the standard against which some aspects of student performance can be measured. The model controller will provide a prioritized list of advisories which are correct at a given time during the approach. This list will also be used by the demonstration/prompting system element to select appropriate R/T for verbalization.

PERFORMANCE MONITOR – A system element must record all aspects of the student's performance and the state of the environment so that performance can be graded and replay provided.

PERFORMANCE MEASUREMENT AND SUMMARY – This system element will score the completed problem and provide student and instructor feedback. Scoring will most likely be done on completion of the run because the instructor must have the ability to resolve misrecognitions before the P run is scored, and the availability of the correction advisory requires deferred scoring. The performance measurement algorithms must be sophisticated enough to score only those elements for which the trainee is responsible. Thus for example, the omission of range calls in level 2 would not be scored. Furthermore, the scoring criteria must be level specific to allow for the development of skill with practice. Finally, subtle deficiencies in control must be detected such as encouraging S turning or porpoising, or consistently thinking out loud, as evidenced by giving the last glidepath position before calling trend and current position.

The student feedback must include specific, constructive criticism and praise. Encouragement must not be neglected.

The performance summary provided to the instructor must give an intelligible account both of the student's performance, and of the training system's decisions to advance, provide remediation, etc. Since this is an experimental prototype, not an operational training system, such feedback is essential to enable the instructor to develop confidence in the system and to detect any deficiencies which should be corrected.

CORRECTION MONITOR – The student will have the option of correcting an R/T error by saying "correction" immediately following the incorrect advisory. A system element is required to monitor every advisory and stop any pilot action undertaken in response to the advisory which is cancelled. The correction will also be noted in the performance file and will not be

scored. (An excessive number of correction messages will degrade the score, however.) The determination of which message is to be cancelled will require some care. Sometimes partial phrases are spoken, an error recognized, and "correction" used, e.g. "slightly above...correction... above glidepath." The first phrase will likely go unrecognized, and no pilot response will have been initiated. Also, the word "correction" must be distinguished from the azimuth trend message "correcting."

INSTRUCTOR KEYBOARD INPUT PROCESSOR – A system element will be required which will accept and interpret inputs at the instructor console. The functions available on request will include:

a. Initiate and terminate GCA-CTS.

b. Display menu of legal entries.

c. Freeze exercise, continue.

d. Display status of training, including explanations of GCA-CTS' decisions.

e. Print student performance information, with explanations of progress.

f. Create a new VRP to replace an existing one.

g. Specify a mandatory replay of the current run.

h. Override current problem selection. (This can be used only to select a previous problem or to advance to the next sequential problem after VRP collection is complete.)

i. Display messages posted by GCA-CTS to inform the instructor that special help is required.

j. Resolve misrecognitions during the replay of the P run.

STUDENT KEYBOARD INPUT PROCESSOR – A system element will be required which will accept and interpret inputs at the student console. The functions available on request will include:

a. Sign on, check out.

b. Display menu of legal entries.

c. Display performance information.

d. Validate voice data.

e. Request replay of the previous run.

SPEECH SYNTHESIZER CONTROL – A system element will be required which will output information via the speech synthesizer upon request, and will notify the requestor when the output is complete. This feature may be used for such things as rule presentation during replay, and for simulation of the verbal behavior of the feeder controller and pilot. Pilot and feeder controller verbalizations are shown in Appendix B.

AUDIO DEVICE CONTROL – A system element will control the recording and playback of the utterances stored on the audio device. The device itself must have the capability to store the audio portion of at least one and preferably three PAR approaches, including both the student's and the system's utterances. A complete PAR approach takes from three to five minutes, depending upon the speed of the aircraft. Actual verbalization is going on for at least half of that time. Some means for time tagging or making individual utterances in such a way that they can be correlated with environmental simulation conditions and SUS outputs during replay must be available. Finally, the system must be able to access individual utterances for selective playback.

APPENDIX A

PHRASEOLOGY TO BE RECOGNIZED

1) "Position X, Roger" X-Numeral (single digit)
2) "C/S, Radar, Button X" C/S - call sign of aircraft (e.g., (Navy), XXX - 3 digits)
3) "Give me Button X"
4) "C/S, This is your final controller, how do you hear me"
5) "How do you hear me now?"
6) "C/S, turn right heading XXX, over"
7) "C/S, turn left heading XXX, over"
8) "Wheels should be down, over"
9) "On the go, C/S, Button X."
10) "On glidepath"
11) "Above glidepath"
12) "Below glidepath"
13) "Slightly above glidepath"
14) "Slightly below glidepath"
15) "Well above glidepath"
16) "Well below glidepath"
17) "Coming up"
18) "Coming down"
19) "Going further above glidepath"
20) "Going further below glidepath"
21) "Going above glidepath"
22) "Going below glidepath"
23) "Execute missed approach"
24) "Climb and maintain 1500, turn right, heading 300"
25) "Heading XXX"

26) "C/S, approaching glidepath, over"

27) "Approaching glidepath"

28) "Begin descent"

29) "C/S, missed approach, (map position), Button X."

30) "Well right of course, turn left heading XXX"

31) "Well left of course, turn right heading XXX"

32) "Well right of course, correcting"

33) "Well left of course, correcting"

34) "Slightly left of course"

35) "Slightly right of course"

36) "On course"

37) "X mile(s) from touchdown"

38) "At decision height"

39) "At decision height, too X_1 for safe approach, if runway not in sight, X_2"

X_1 = 1) high
2) low
3) far right
4) far left

X_2 = 1) execute missed approach
2) climb and maintain 1500 turn right heading 300

40) "Wind XXX at X (x), cleared for X_1"

X_1 = 1) low approach
2) touch and go
3) to land

41) "C/S, do not acknowledge further transmissions"

42) "Transmission break"

43) "Over landing threshold, (position in relation to centerline), over."

44) "Over"

45) "Contact tower after landing, over"

46) "Button X, clear"

47) "Turn right, heading XXX."

48) "Turn left, heading XXX."

49) "Correction"

50) "Right of course, turn left heading XXX."

51) "Left of course, turn right heading XXX."

52) "Right of course, correcting."

53) "Left of course, correcting."

54) "C/S, heading XXX, over."

APPENDIX B

PHRASES TO BE SIMULATED

1) "Position $\underline{X}_1$ hand-off, 1, 2, 3, 4, button $\underline{X}_2$

X_1 = number (1-3)

1. = Aircrafts position e.g., 1. right base
   2. left base
   3. distance and direction

2. = Aircraft's call sign
   $\underline{1}$, $\underline{2}$, $\underline{XXX}$

   X = number zero-niner

   1 = Navy, Air Force, Army, Marine, Coast Guard, November, Bravo Hotel

3. = Type of aircraft

4. = Type of approach

   1 = Full-stop
   2 = Low approach
   3 = Touch & go
   4 = All of the above in no-gyro
   5 = Short approach

X_2 = Radio frequency that aircraft is on (digit-button number)

2) "After completing low approach climb and maintain 1500, turn right heading 270, over"

3) "Your missed approach procedure is climb and maintain 1500, turn right heading 300, over"

4) "Turn right heading 130, over"

5) "Turn right heading 140, over"

6) "Turn left heading 180, over"

7) "Turn left heading 190, over"

8) "Position $\underline{X}$, where is $\underline{C/S}$"

9) "Position $\underline{X}$, did you copy?"

10) "Position X, over"

11) "C/S, radar contact"

12) "Loud and clear, out"

13) "Weak but clear"

14) "Roger, turn left heading XXX"

15) "Roger, turn right heading XXX"

16) "Roger, out"

17) "Roger"

APPENDIX C

PHRASES TO BE RECOGNIZED FOR THE ENRICHMENT PROGRAM

1. "C/S, this will be a no-gyro approach, over."
2. "This will be a no-gyro approach."
3. "Make one half standard turns."
4. "C/S, turn right, over."
5. "C/S, turn left, over."
6. "C/S, stop turn, over,"
7. "Turn right."
8. "Turn left."
9. "Stop turn."
10. "Radar contact lost, if runway not in sight climb and maintain 3000, turn right, proceed direct point bravo, hold until advised by GCA, over."
11. "Radar contact lost, climb and maintain 3000, turn right, proceed direct point bravo, hold until advised by GCA, over."
12. "Climb and maintain 3000, turn right heading 270."
13. "Low altitude alert, check your altitude immediately."
14. "Execute missed approach."

APPENDIX D

NOTES ON NAVTRAEQUIPCEN TN-52

An important reference for the present document has been Technical Note NAVTRAEQUIPCEN TN-52, Training Characteristics of the Automated Adaptive Ground Controlled Approach Radar Controller Training System (GCA-CTS). Since this document was published in 1976, some changes have been made in the training program at NATTC and are reflected in this report. The differences are listed in table D-1. Table D-2 gives a list of the behavioral objectives which are not addressed in TN-52.

TABLE D-1. DIFFERENCES BETWEEN TN-52 AND THE CURRENT REPORT

TN-52 Reference	Comment
p. 11	The touching and paralleling course rule is no longer considered to provide adequate control.
2.3.2, p. 23	The number of sweeps is not counted as a timing mechanism in no-gyro approaches.
2.4b	The execute missed approach option is given under the specified conditions only at decision height because after that time the pilot is assumed to have the runway in sight.
2.5c, p. 24	"Over landing threshold, over" is acceptable if the aircraft is on course.
2.7.4	A new uniform clearance light system is being installed throughout the fleet, thus it is not necessary to simulate 3 types as described.
3.3.1, p. 25	The advisory "assigned heading XXX" has been replaced by "heading XXX." In addition, use of course position messages is encouraged throughout the approach.
3.3.4, p. 26	The no-gyro approach will be included as an enrichment topic and is not included on the P run.
4.4f, p. 30	Track histories are not given now. Missing a glidepath position message can be excused if another message had higher priority.
p. 32	The scoring algorithms will be modified.

TABLE D-2. OBJECTIVES NOT IN TN-52.

Table Number	Item	Description
1	1, 2, 3, 4, 5	Checking radar alignment
2	1, 2	Servoing to maintain radar contact
3	1, 2, 3, 4	PAR controller — pattern controller dialog
8	1, 2	Course position advisories
14	1	Transmission break
17	2, 3	Rollout instructions, ICS dialog
18	2	Verification of handoff
21	1	Low altitude alert

APPENDIX E

BEHAVIORAL OBJECTIVES – SYLLABUS CROSS REFERENCE

In Table E-1, the behavioral objectives have been numbered with a "B" followed by mission objective number and terminal and enabling objective numbers as appropriate. The corresponding syllabus tasks are numbered according to the scheme used in Tables 23-33.

TABLE E-1

Behavioral Objectives	Behavioral Objectives Tables – Cross Reference			Syllabus – Tables Cross Reference		
Hierarchy Number	Table	Objective	Page	Table	Task	Page
B1	1-2			24, 26	T2.1, .2, .3, .4, T4.1, .2	75, 87
B1.1	1		14-15	24, 26	T2.1, .2, .3 T4.1	75, 87
B1.1.1	1	1	14	24	T2.1	75
B1.1.2	1	2	14	24	T2.2	75
B1.1.3	1	3	14	26	T4.1	87
B1.1.4	1	4	14	26	T4.1	87
B1.1.5	1	5	15	26	T4.1	87
B1.1.6	1	6	15	24	T2.3	75
B1.2	2		17	24, 26	T2.4, T4.2	75, 87
B1.2.1	2	1	17	24	T2.4	75
B1.2.2	2	2	17	26	T4.2	87
B2	3			24, 26, 27, 28	T2.8, .12 T4.3, .4, .5, T5.2, T6.2	77, 79, 89, 96, 99
B2.1	3		20-23	28	T6.2	99
B2.1.1	3	1	20	28	T6.2	99
B2.1.2	3	2	21	28	T6.2	99
B2.1.3	3	3	21-22	28	T6.2	99
B2.1.4	3	4	22	28	T6.2	99
B2.1.5	3	5	22-23	28	T6.2	99
B2.2	4		26-27	24, 26, 27	T2.8, .12 T4.3, .4, .5, T5.2	77, 79, 87, 89, 96
B2.2.1	4	1	26	24	T2.8	77
B2.2.2	4	2	27	24	T2.12	79
B2.3	5		29-30	26	T4.3, .4	87, 89
B2.3.1	5	1	29	26	T4.4	89
B2.3.2	5	2	29-30	26	T4.3	87
B2.4	6		32	26, 27	T4.5, T5.2	89, 96
B2.4.1	6	1	32	26	T4.5	89
B2.4.2	6	2	32	27	T5.2	96

TABLE E-1

Behavioral Objectives	Behavioral Objectives Tables – Cross Reference			Syllabus – Tables Cross Reference		
Hierarchy Number	Table	Objective	Page	Table	Task	Page
B3				24, 25 26, 27	T2.11, .13 T3.1, .2, .3 .4, .5, .6, .7 T4.6, .7, .8	79, 81, 85, 86, 89, 90, 96
B3.1	7		35-36	24	T2.11, .13	79
B3.1.1	7	1	35-36	24	T2.11, T2.13	79
B3.2	8		37	25	T3.1, .2, .3	81
B3.2.1	8	1	37	25	T3.1, .2	81
B3.2.2	8	2	37	25	T3.3	81
B3.3	9		39	25	T3.4, .7	81, 85
B3.3.1	9	1	39	25	T3.4	81
B3.3.2	9	2	39	25	T3.7	85
B3.4	10		41-42	26	T4.6, .7, .8	89, 90
B3.4.1	10	1	41	26	T4.6, .7, .8	89, 90
B3.4.2	10	2	41-42	26	T4.6, .7, .8	89, 90
B3.5	13		45-46	25	T3.5, .6	85
B3.5.1	13	1	45	25	T3.5	85
B3.5.2	13	2	45-46	25	T3.6	85
B3.6	14		48	27	T5.1	96
B3.6.1	14	1	48	27	T5.1	96
B3.7	15		50	25	T3.8	86
B3.7.1	15	1	50	25	T3.8	86
B3.7.2	15	2	50	25	T3.8	86
B4				27, 28	T5.3, T6.1	97, 99
B4.1	16		53	27	T5.3	97
B4.1.1	16	1	53	27	T5.3	97
B4.1.2	16	2	53	27	T5.3	97
B4.2	17		55	28	T6.1	99
B4.2.1	17	1	55	28	T6.1	99
B4.2.2	17	2	55	28	T6.1	99
B4.2.3	17	3	55	28	T6.1	99

TABLE E-1

Behavioral Objectives	Behavioral Objectives Tables — Cross Reference			Syllabus — Tables Cross Reference		
Hierarchy Number	Table	Objective	Page	Table	Task	Page
B4.3	18		57	28, 33	T6.1, T9.4	99, 105, 106
B4.3.1	18	1	57	33	T9.4	105, 106
B4.3.2	18	2	57	28	T6.1	99
B5						
B5.1	19		59-60	30, 31	T9.1, T9.2	102, 103
B5.1.1	19	1	59	30	T9.1	102
B5.1.2	19	2	59	30	T9.1	102
B5.1.3	19	3	60	30	T9.1	102
B5.1.4	19	4	60	31	T9.2	103
B5.2	20		62	32	T9.3	104
B5.2.1	20	1	62	32	T9.3	104
B5.3	21		63	33	T9.4	105
B5.3.1	21	1	63	33	T9.4	105

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